OPERATIVE TECHNIC

IN

GENERAL SURGERY

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Edited by WARREN H. COLE, M.D., F.A.C.S., Professor of Surgery and Head of the Department, University of Illinois College of Medicine; Chief Surgeon, Illinois Research and Educational Hospitals, Chicago

With 67 contributing authors *SECOND EDITION*

Introduction by Frank H. Lahey



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To my wife

Clara

without whose patience and understanding

editorship of this work could not have

been accomplished

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SURGERY OF THE STOMACH AND DUODENUM

Preface

Included in this volume are the subjects more strictly in the realm and of interest to the general surgeon but which will be found valuable for the young surgeon training in the various specialties of surgery. An accumulating amount of evidence appears to emphasize the importance of a basic training in general surgery as either preliminary or supplemental training for the specialties of surgery. Basic knowledge of surgery including familiarity with hemorrhage, shock, infection, effects of trauma, pre- and postoperative care, etc., would appear to be desirable for all surgical specialists. Surely the specialist will profit by a detailed study of these phases of surgery which have always received meticulous attention in general surgery.

There is a definite tendency to include thoracic and vascular surgery in the training of the general surgeon. These two chapters, however, are included in Volume Two because of lack of space.

Extensive changes have been made by the contributing authors in the revision of this volume, and many new illustrations have been added. Three new chapters have been included, one on "Blood Transfusions and Allied Problems" by Dr. J. Garrott Allen, the second on "Gastrointestinal Surgery in Infancy and Childhood" by Dr. William Riker, and the third on "The Appendix" by Dr. John Reynolds. To make room for these new chapters, three chapters formerly appearing in the first edition of this volume have been transferred to Volume Two.

Great advances have been made in nearly all subjects since the last edition. Important progress has been made in surgical physiology (pre- and postoperative care), pediatric surgery, and surgery of the esophagus, pancreas, and breast. Regrettably, much of the progress achieved in surgery must be made on the basis of trial and error. For example, the five-year survival rate following resection of the pancreas for carcinoma could not be determined until a significant number of resections had been done in numerous clinics throughout the country and time allowed to determine long-term results. Sufficient time has now elapsed since this operation was designed for us to learn that the five-year survival rate is very low (perhaps no more than 5 per cent), although it is as high as 25 per cent for carcinoma of the ampulla of Vater. Likewise, we are now in the process of trying to find out if a more radical operation for carcinoma of the breast will yield better results. Also, in recent years, rather massive resections of liver tissue are being carried out in favorable cases for primary and secondary malignant tumors. Years will be required to determine if these operations are really worth while, i.e., will yield [illegible] the postoperative deaths

We are not changing the foreword in this edition but are retaining the one written by the late Dr. Lahey because he expressed adequately the purpose of the volume which of course remains the same.

The editor wishes to thank the various authors for their splendid contributions and for their excellent cooperation. The untiring efforts of Miss Annabel Wheeler, Miss Joanne Hansen, Mrs. Jeanette Weil, and Dr. John Schneewind in the preparation of the text and the index are likewise acknowledged. At all times the publishers have been most cooperative.

WARREN H. COLE

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Introduction

In producing this book, *Operative Technic in General Surgery*, the authors, the editor and the publishers have ably met a real demand and that is the presentation of methods of performing surgical operations brought up to date by a variety of busy surgeons actively engaged in the performance of the operative procedures which they have described and in sufficient numbers from which to draw deductions and to advocate sound procedures.

We in surgery are interested in the investigative work upon which is established all sound surgical procedures. We are interested in the diagnosis upon which depends so much the selection of proper measures to meet the conditions which require treatment. We are interested in the decision for or against surgery. In spite of our interest in all of these points which constitute the foundation of a surgical problem, the ultimate controlling factors which will bring about surgical relief or failure to relieve are the selection of the operation and its proper technical performance.

In order to select the proper type of surgical procedure for any given case, one must obviously be familiar with all of the types of surgical operations applicable to that case in order to weigh one against the other and to make the proper choice of the type of operation for that patient.

Serious criticisms have at times been directed particularly against clinical surgeons because of their occasional overemphasis of technical procedures. There undoubtedly have been surgeons whose interest has been overbalanced on the side of technic, sometimes at the expense of more fundamental things. There undoubtedly have been surgeons who have become such adept technicians and so confident of their technical ability that they have been led into unwise decisions and unwise surgical procedures. Nevertheless, one must admit that the proper selection and the proper technical performance of the surgical operation are the final deciding factors in the attempt to cure any surgical lesion by an operation.

This book has the great advantage of having the various subjects presented by men who have had experience with the particular subject about which they write.

The field of surgery today is so wide and surgery itself is so complex that no one is capable of great technical expertness, really based upon a large experience, except in a relatively limited number and types of operative procedures. My own long and fairly large surgical experience has taught me with increasing contact with surgery that one must realize that it is impossible for a surgeon to attain great technical skill in any given operative procedure except by a special interest in the procedure and by performing it over and over again.

This contribution to operative technic in general surgery complies with all of these requirements. The names of these various authors appear frequently in the world literature on the subjects which they present in these volumes. They are still young enough to be flexible in their viewpoint and to be interested in newer and modern developments in surgery. They are, however, sufficiently mature to have had time and opportunity to acquire a volume of experience which makes them capable of presenting their subject with authority.

FRANK H. LAHEY

OPERATIVE TECHNIC
IN
GENERAL SURGERY

1

WOUND HEALING AND THE CARE OF WOUNDS

EDWARD L. HOWES

Operative technic is a craft that depends on knowledge of how the wound heals. From this knowledge one learns what can be accomplished by the regeneration and transplantation of tissues, how much time is needed, and what complications must be avoided to obtain the greatest possible function. Until recently, types of operations were followed like recipes. Repetition insured that a successful outcome would be obtained if nothing unusual was encountered. However as we have become increasingly knowledgeable about the expected reaction patterns to injury of the various tissues of the body, the application of this knowledge has made us increasingly able to deal with the unusual and sometimes to wonder whether the recipes are correct. There is no greater safeguard against morbidity than a well founded awareness of what care is required to insure optimal healing.

THE EXUDATIVE PHASE OF HEALING

In the days immediately following wounding, the exudative phase of healing occurs. During this phase, hemorrhage is arrested, fibrin is deposited, bacterial invasion is resisted, dead tissue is liquefied and foreign bodies are sloughed. The injured area is corrected chemically to allow the propagation of cells. The initial care of all wounds is directed toward obtaining the shortest possible exudative phase of healing, thereby allowing tissues to regenerate as soon as possible.

Hemorrhage is arrested by the retraction of blood vessels, and the arrest maintained by the deposition of fibrin in the cut ends of the severed vessels. Deposited fibrin also seals together tissue layers, acting as a glue between serosal surfaces. It provides a watertight and airtight seal and thus prevents leakage from wounds of hollow viscera immediately after suturing (Fig. 1-1). Fibrin anchors particulate matter, including bacteria, in one location in the wounded tissues.

Resistance to bacterial invasion and liquefaction of dead tissue is accomplished by the vascular and cellular reaction. After vasodilatation, exudate is poured into the injured area causing a transitory edema. Phagocytosis and an antibacterial enzyme—lysozyme—hinder the growth of, and destroy, the bacteria, while enzymes liberated by the leukocytes liquefy dead tissue and thereby rid the area of food stuff for the growth of bacteria. Toxic by-products are carried away by the blood stream. A jelly-like matrix seeps through the cells of the uninjured vessels into the area, and new capillaries begin to sprout from old blood vessels. These capillaries start to grow about 72 hours after the injury but usually do not appear grossly until about the

fourth day after the injury. Leukocytes are gradually replaced by mononuclear cells, and some of these are soon recognized as fibroblasts.

The exudative phase lasts about four days in optimal healing. During this phase the sutured wound has only the strength imparted by the sutures and deposited fibrin. In fact, the wound loses some of the immediate strength given by the sutures because the tissues partly lose their capacity to hold sutures through edema and liquefaction of tissue.



Fig. 1-1 Histologic features in the repair of peritoneum In the center of the photograph can be seen the inverted approximated edges of the peritoneum Stretching across the v-shaped cleft at the bottom of the photograph is deposited fibrin Serosal surfaces should always be inverted when sutured, to place them in apposition so that fibrin can be deposited

In the open wound, healing optimally, nothing seems to happen grossly during the exudative phase except that a small amount of serum escapes. Carrel and Du Nouy(1) called this the latent period of healing—a stage of apparent inactivity when the mechanisms that bring about the redintegration of the tissues are progressively set into motion. The exudative phase terminates with the appearance of granulations, and then the wound begins to contract.

THE TISSUES REGENERATED

During the next six days three tissues are proliferated; blood vessels, epithelium, and fibrous tissue. These three comprise the scar or cicatrix. An abundant new growth of blood vessels is essential for the regeneration of epithelium and fibrous tissue. The primary objective in the treatment of

the wound is to establish conditions that will allow these tissues to regenerate early and properly, to restore continuity and function.

Generated * fibrous tissue restores the continuity of the deeper tissues. Thus, wounded muscle, fat, liver, spleen, kidney, lung, and serosal surfaces are reunited and replaced by it. Regenerating epithelium re-covers surfaces, and the process is essentially the same for both skin and mucous membranes.



Fig. 1-2. Regeneration of skin. The defect is on the left. The single layer of cells advancing from the germinal layer of the thickened uninjured epithelium on the right can be seen in the middle of the photograph, extending for a considerable distance over the granulations. (From Howes, Surg., Gynec. & Obst., 76:738, 1943.)

Epithelium regenerates only from preexisting epithelium; from that about the margins of the wound and from islands left in the wounded area(2). The process of epithelization consists of 1, hyperplasia and hypertrophy of preexisting epithelium; 2, ameboid motion of epithelial cells extending outward over the defect from the germinal layer of the old epithelium; and 3, restratification and keratinization of this single layer of cells to reform a new epithelial structure that incompletely resembles the original (Fig. 1-2). Regenerated skin, for example, is without sebaceous glands or hair follicles. Restratification and keratinization, differentiation of the epithelial scar, occur promptly after the single layer of cells moves out from the germinal layer, and the process is complete within a day or two after the area is covered with the single layer of cells(4). Thereafter, the only change

* The term generation is used to emphasize that fibrous tissue appears in areas where it did not exist previously.

upon the vessel distal to the wound also. The pressure must be maintained until ligature of the vessel or control with a hemostat can be effected. Every physician and person trained in first aid should be thoroughly familiar with the *six major pressure points.* These points are described by Cole and Puestow[65] as follows:

"*Compression of the Temporal Artery.*—The pulsations of this artery may be felt on the temple, one finger width in front of the ear, flush with the level of the tragus, the small triangular piece of cartilage which borders the ear canal in front. The artery supplies the region of the temple and part of the scalp (Fig. 4). Because of the rich blood supply of this region, it may be necessary to apply direct pressure on the wound against the bone, or apply pressure on both sides of the wound.

"*Compression of the External Maxillary (Facial) Artery.*—This is done for bleeding wounds of the face, below the eye and above the jawbone. This artery is located as it crosses the jawbone at the posterior third of its horizontal branch, where the front edge of the masticator muscle crosses the bone. The artery supplies the cheek and the lateral lining of the mouth. Its compression against the jawbone is readily accomplished (Fig. 4).

"*Compression of the Common Carotid Artery.*—For bleeding from wounds in the neck, in the mouth, or the throat, this important vessel can be found by first feeling for the trachea (windpipe) in the middle of the neck and then running the tips of the second, third and fourth fingers horizontally over the neck until the pulsations of this large vessel are encountered. If the patient's head is bent back by placing a small pillow under the shoulder blades, the carotid artery will become more superficial and will be very obvious at the inner edge of the large muscle (sternomastoid), which serves to bend the head forward (Fig 4) Three fingers are placed on this vessel, whereas the thumb is carried around the back of the neck. Pressure should never be exerted toward the windpipe but toward the thumb In this way, the vessel will be compressed against the spinal column. This vessel supplies all the structures of the head and neck, including most of the brain Prolonged pressure on it, especially in patients over 45, may lead to damage of the brain. Pressure should always be exerted at a point lower than the Adam's apple (larynx) At this point the vessel divides into its two main branches. Pressure on this area may lead, in certain individuals, to slowing of the pulse, a great fall in blood pressure and even a standstill of the heart. The best site to exert pressure is in the lowest part of the neck, where the spinal processes become prominent.

"*Compression of the Subclavian Artery.*—For bleeding from the extreme upper part of the arm, the armpit or the shoulder, this artery may be compressed in the hollow just above the collarbone. In slender individuals, with long necks and sloping shoulders, the artery may be well felt above the inner third of the collarbone, especially if the corresponding shoulder is pulled down. In stocky, short necked individuals, not only is there a great deal of soft tissue between the skin and the artery, but the artery may never rise above the level of the collarbone and, therefore, cannot be reached by pressure It should be kept in mind that if the pulsations of the artery are not readily felt, no time should be lost in trying to compress it against the first rib. In such cases direct pressure will have to be applied against the bleeding surface.

"*Compression of the Brachial Artery.*—This is the main artery of the arm. Its pulsations can be felt in the groove behind the biceps muscle, especially if the arm is lifted away from the body at right angles and the arm rotated outward so that the palm of the hand faces upward (Fig. 4). The artery is compressed against the bone at the middle third of the upper arm by grasping the arm firmly with three fingers in the groove at the edge of the biceps and the thumb on the outside. When pressure is correctly applied, the pulse at the wrist should disappear. Pressure below this level is not indicated, as branches of the brachial artery will continue to supply blood to the wound and can be controlled only by means of a tourniquet.

"*Compression of the Femoral Artery.*—This is the main artery of the lower extremity. It lies superficially in the groin and its pulsations can be felt easily, even in obese individuals, if the middle of the inguinal fold (groin) is gently felt. The artery can be compressed here against the flat plate of a pelvic bone (Fig. 4). The pulse in the foot should disappear when compression is adequate. Only if the patient is very weak and has lost much blood will the pulse be feeble or imperceptible. The entire palm of the hand will have to be pressed into the groin."[66]

In an emergency, a patient will telephone his doctor in regard to bleeding which he considers extremely serious. The physician can accomplish a great deal of good by instructing him to apply firmly to the bleeding point a sterile

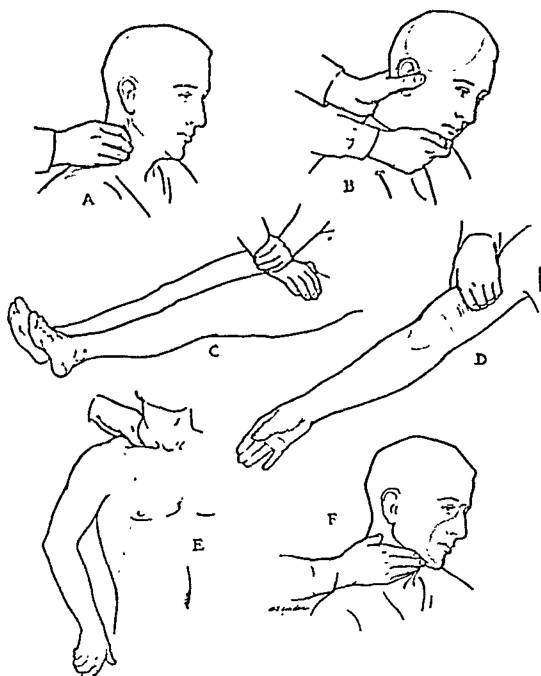


Fig. 4.—Illustration revealing the six major pressure points, indicating compression of the artery for control of hemorrhage. Pressure over A, the carotid; B, temporal artery; C, femoral artery; D, brachial artery; E, subclavian artery, and F, external maxillary or facial artery. The shaded portions represent the areas where the arterial circulation is impaired by the pressure. (Cole, W. H., and Puestow, C. B.: First Aid, New York, D. Appleton-Century Company, 1942.)

compress or, lacking a sterile compress, simply a clean cloth. The pressure should be continuously applied until the hemorrhage has subsided. An anxious patient often will remove the pad too frequently and not afford a chance for the clot to form.

Elevation of the affected part will lower the local blood pressure, both arterial and venous, to such an extent that bleeding will be greatly diminished. If the proper facilities present themselves and if an isolated bleeding vessel can be found, *grasping the vessel with a hemostat* or artery clamp and ligating it is the most efficacious way of controlling bleeding. However, in the case of minor surgical wounds this rarely is required. Wounds of the scalp bleed profusely, and it is a common experience of interns and others to spend considerable time attempting to isolate, clamp and ligate the bleeding point. A much better procedure is the suture of the wound itself, taking deep bites in the skin, and the application of a firm dressing over the wound. In many cases the bleeding will stop with pressure or with no treatment at all. Large oozing surfaces of capillary bleeding are best controlled by the application of hot packs. Small wounds, such as razor cuts and small abrasions, may have their bleeding stopped by pressure or by application of styptics, such as alum, tannic acid and ferric chloride, or by coagulating agents, such as thrombin.

Absorbable gelatin sponge* is a valuable hemostatic agent, particularly for broad oozing surfaces. It may be used with thrombin, and according to Evarts Graham is particularly useful in control of hemorrhage from small vessels in scar tissue.[67]

In *hemophilia* there is a prolonged clotting time of the blood. This disease, which is hereditary, is transmitted only by females and occurs almost exclusively in males. According to Minot,[68] pin-pricks do not cause bleeding, but scratches may initiate serious hemorrhage. The veins and ears may thus be punctured with impunity, indicating that the bleeding time is normal. These authors say that the disease tends to become fatal before the subject attains adult life. In cases of hemorrhage in individuals with hemophilia, absolute quiet is essential. Locally tissue-juice extracts should be applied. Fresh meat tissue is serviceable in an emergency. Thrombin, topical (Parke, Davis & Co.), is valuable. Silver nitrate and alum are useful for small areas, and gelatin sponges are of value. (See section on gelatin sponges elsewhere.) Injections of thromboplastin may be of use. In severe cases blood transfusion may be a life-saving measure. It not only will replace the lost blood but will supply coagulants.

Minot and Buckman say: "The use of protein sensitization in the treatment of hemophilia is noteworthy. The *nonsensitive* patient is given 3 to 4 cc. of sheep or horse serum subcutaneously. After ten days he will usually be sensitive and should then receive about 0.2 cc. of the same serum intradermally. As the skin reaction becomes positive, the coagulation time of the blood often falls, and if bleeding is in progress it will probably stop. The effect may last for days or many weeks. The skin reaction does not desensitize the patient, so that he is constantly ready to react to other intradermal injections of the protein solution. These may be given as often as desired to check the bleeding when it arises." Rosenfeld and Lenke[69] believe the direct application of tiger snake venom to be of value in the control of local hemorrhage in patients suffering from such disorders as hemophilia and thrombocytopenia.

Every Boy Scout troop and first-aid class throughout the country has been religiously drilled in the application of *tourniquets*. To the average man the sight of blood invariably invokes the idea of a tourniquet. As a result, the tourniquet has been perhaps much misused and has done more harm than actual good. The venous pressure, being about 8 cm. of water, is greatly lower than the arterial pressure, which, in the average individual, is from 110 to

* "Gelfoam," Upjohn Company, Kalamazoo, Mich

180 mm. of mercury. A common error is to put on the tourniquet tightly enough to overcome the venous pressure but not the arterial pressure, and as a result the bleeding is, and continues to be, more profuse than before the tourniquet was applied. It is a common experience of physicians on arriving at the scene of an accident to remove such a tourniquet and, to the astonishment of those present, see the bleeding stop. Moreover, all such bleeding could have been controlled merely by pressure and elevation. A second error in the application of the tourniquet is its too tight application. The resulting pressure upon the nerve trunks will bring about paralysis, which fortunately generally is only transitory. When it is necessary to use a tourniquet, as in such operations as require a bloodless field, a blood pressure apparatus is far superior, as the actual pressure may then be measured. McElvenny[70] says: "The time a tourniquet can remain in place is only judged by the collective experience of many cases in which satisfactory tourniquets have been applied and released with no disturbances. We have many times kept tourniquets on the lower extremity for two hours with no ill effects, but we believe that no more than ninety minutes for the lower extremity should be advised. Usually by this time the field has been well developed and explored and has become familiar to the operator so that the releasing of the tourniquet is no real handicap. In the upper extremity we believe seventy minutes is about as long a time that a tourniquet should remain in place. If, as is often the case, many minutes will be used in completing the meticulous work so often experienced here, it is advised to release the tourniquet every forty minutes, then elevate the limb and re-apply.

"The pressures for tourniquet application have been given a great deal of attention by us. Generally 250 mm. of mercury for the arm and 570 mm. of mercury pressure for the lower limb is recommended. We have found these to be entirely inadequate and result in leaking past the tourniquet in so many patients as to cause us to increase our pressures routinely.

"For the past five years we have used on the arm a pressure of 350 mm. of mercury as shown on the blood pressure cuff as a routine. This pressure has given excellent tourniquets and no complications. We have kept tourniquets at this pressure on for as long as ninety minutes. In the lower extremity the standard pressure adopted by us has been twenty-two pounds as read on the gauge. These have not leaked, while at twenty pounds some of the tourniquets have leaked. No ill effects from this pressure have occurred." Speigel and Lewin[72] report three cases of surgically proved peripheral nerve damage following the use of a rubber tourniquet. There are very few uses for the tourniquet in the realm of minor surgery. In first-aid work its use is reserved for such major accidents as traumatic amputations of extremities, causing a large artery, such as the femoral or the brachial, to bleed. In this case any material, such as a belt, handkerchief, rope or cord, should be twisted about the extremity proximal to the bleeding point and tightened until the bleeding ceases. In such cases it is advisable momentarily to release the tourniquet every hour to flush the parts distal to it with blood and thus to lessen the danger of gangrene in tissues which might be saved. Blalock[71] says: "Use of a tourniquet on an injured extremity should be avoided whenever possible, but . . . if some form of constriction is necessary the temperature of the distal ischemic and anemic part should if possible be lowered by artificial means."

Anesthesia.—Many minor surgical wounds may be treated without inducing

anesthesia. By most adults of stable temperament the introduction of a few sutures with a sharp cutting needle and fine suture material is well borne. For young children, however, and nervous adults some form of anesthetic will usually be necessary. For children with wounds about the face, where immobility is necessary for accurate suturing, general anesthesia is preferred. For adults local or general anesthesia may be used. The use of *local anesthesia* should be more generally employed. Its omission generally indicates that the physician is unprepared to administer it or is too lazy to do so. For skilful administration, the finest type of needles is required. A no. 27 gauge hypodermic needle with a *short* bevel may carefully be inserted into the skin through the wound edges and the skin and subcutaneous tissues carefully infiltrated (Fig. 5). Mont Reid[73] advises that the infiltration of the skin be made "well away from the edges of the wound." The suturing then may be

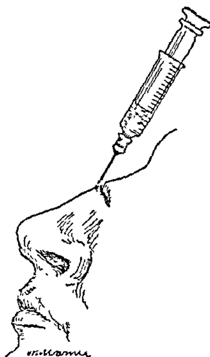


Fig. 5.—Method of infiltrating a wound with local anesthetic solution preparatory to wound suture.

accomplished without any discomfort to the patient. *Two per cent butyn solution* has proved to have considerable value as an anesthetic agent when *applied topically to abrasions* and when *injected into wound margins*. The placing of novocain crystals or strong solution of novocain in the wound will be helpful.

Sodium pentothal is useful if someone thoroughly versed in its administration is available to give it. Procaine (novocain), being a derivative of para-aminobenzoic acid, is an inhibitor of the sulfonamides. Hanrahan[74] says: "If procaine is injected at least 3 cm. away from a wound and proximal to it, or particularly if used for nerve or regional block, there is little reason to believe that the bacteriostatic effect of the sulfonamide implanted in a wound would be materially lessened."

For a more detailed account of local anesthesia see chapter XXIII.

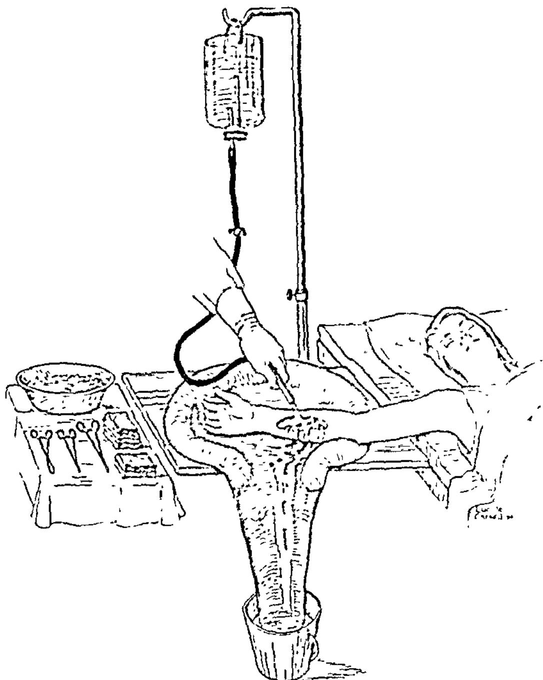


Fig. 6.—Method of cleansing a fresh wound. For purposes of clarity the sterile towel which is placed under the arm is omitted so that the Kelly pad may be better seen. At the left is a small set-up on a table consisting of sterile instruments, sterile pledgets of gauze and a solution of soap suds. The soap solution is made from white soap flakes in tepid or warm water and is agitated so that a real suds is formed. A pledget of gauze is first placed on the wound, and the surrounding skin is thoroughly cleansed with the soap solution and washed with water. The pledget is then removed from the wound, and the wound itself is then cleansed with the soap solution and washed with sterile water. This is done repeatedly; finally a prolonged irrigation with sterile water is carried out. After this the Kelly pad is removed and the arm is redraped with sterile towels.

Cleansing and Preparation of the Wound.—No one should undertake any procedures necessary to the care of a wound without being properly masked and wearing sterile gloves and gown.

The importance of proper cleansing with soap and water cannot be overemphasized.

"The first consideration in the treatment of wounds is that they be given prompt attention. The sooner treatment is instituted the more likelihood of rapid primary healing. After six hours, the contaminated wound is usually converted into an infected wound. . . . If the patient is a child or if the wound is anything larger than a small incised wound, the patient will be anesthetized. General anesthesia is usually the best, but where this is not convenient an infiltration of the skin outside of the wound edges will be advisable. A pledget of gauze moistened in novocain solution placed in the wound has some value. Once anesthesia is secured, a fluff of sterile gauze is placed in and over the wound. The skin around the wound is then thoroughly cleansed. If grease is present it will be removed by benzine or ether. Hair, if present, will be clipped and then shaved for a distance of ½ of an inch from the wound border, abundant soapy lather and a sharp razor being used. The skin will then be very carefully cleansed with soap and water for five to ten minutes. White soap flakes, if well mixed with warm, sterile water, will make an excellent lather. The soap solution should be agitated with sterile gauze until a heavy suds is obtained. A stiff brush is likely to traumatize the skin and should be discarded in favor of a soft brush or fluffed-up gauze. A Kelly pad may be placed under the extremity to drain the washings conveniently into a pail. After a minute of cleansing with soap, the latter is washed off with sterile water and soaping is resumed. This process is repeated five or six times. The protecting gauze is then removed from the wound, and the wound itself is cleansed by repeated soapings and repeated irrigations. All corners and recesses are cleansed with the soapy solution and the irrigation with sterile water or saline solution. A sterile irrigating jar or can is a valuable addition to the accident room. The hose of the irrigating outfit may be used to direct the stream of the irrigating solution into all parts of the wound (Fig. 6). During this five to ten minute period of cleansing the wound, most of the dirt and other foreign bodies will have been removed. Some larger foreign bodies will have to be lifted out of the wound with a forceps or gently moved out with applicators. A final irrigation will now be done (Fig. 6). Large quantities (2 or 3 quarts) of irrigating solution will be used. *No antiseptic of any kind is used* in the wound or on the surrounding skin."[75] The use of an antiseptic solution on the surrounding skin is advocated by some surgeons and is not objectionable.

The following story of Mont Reid's[73] is illuminating and instructive:

"Not long ago a friend of mine brought his boy hurriedly to my home because of a laceration of the end of his thumb. If the boy had not held his wound under running water the father would not have been so worried; he would have put some iodine on it and

[illegible]

for a week unless he should show an elevation of temperature or complain of pain. No antiseptics were used in the open wound. There was practically no pain and no fever. At

[illegible]

occasion had always been to kill the germs at whatever cost in pain, suffering and infection. He could only shake his head and say, 'I do not understand.'

"This father's attitude reflects, I believe, the viewpoint of the average layman today with regard to the handling of trivial wounds and probably that of the vast majority of the doctors of our time with respect to all wounds."[76]

After the preliminary cleansing it is valuable to use a fresh set-up of soap and water, gauze and instruments before proceeding to the cleansing of the wound proper. Webb[77] uses five separate set-ups. Bisgard[78] uses soap on the skin only and normal saline solution for irrigations of the wound in preference to water. He severely condemns the use of tincture of green soap in fresh open wounds. Trueta[79] says, "No antiseptic known today is equal to soap and water as a means of dealing with contamination in a wound." Kerrigan[80] made a study of 12,044 compound wounds and found that hospitalization was necessary in only eighteen cases in which the primary care consisted of white soap and water cleansing and excision of only devitalized tissue. He adds:

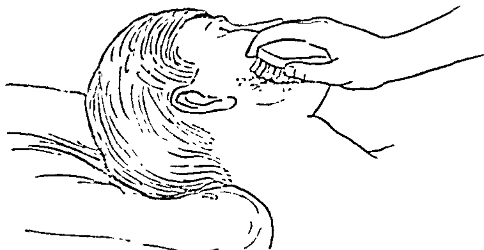


Fig. 7.—Removing embedded cinders from the face with a stiff brush, the patient being under general anesthesia.

"Seventy-five per cent of these compound injuries involved the wrist and hand. Of these 9,195 cases only 10 patients required hospitalization. Because these injuries were so uniformly contaminated and so difficult of cleansing and, further, because in no instance in which primary soap and water cleansing was given was it necessary to hospitalize an individal for infection, [illegible]

[illegible] and in no instance osteomyelitis or delayed union from infection."

The experiments of Peterson[81] indicate "that of the various methods studied the cleansing of contaminated wounds by a *gentle* irrigation with isotonic solution of sodium chloride is the most effective prophylaxis of wound infection. Contaminated wounds treated by this gentle irrigation healed with less evidence of infection than did control contaminated wounds subjected to no treatment other than closure at the specified time. Best results in cleansing these small wounds were obtained by irrigating them with 1,000 cc. of saline solution with no scrubbing, utilizing the force of the stream as the washing mechanism."

In certain cases, in which the face has been forcibly ground into gravel or

cinders, minute foreign particles will be intimately embedded in the skin. All of these should be removed with a stiff sterile brush under general anesthesia (Fig. 7). It is sometimes impossible to remove these particles entirely, and more or less permanent discoloration will take place. Likewise in a case of embedded powder grains, removal is desirable. Some authorities advise the scrubbing of the wound surface with a stiff brush dipped in peroxide of hydrogen. Pieces of glass or porcelain tile or other foreign bodies should be searched for with a moderate degree of thoroughness. A vigorous probing and upheaval of the wound is not good technic. The removal of buried foreign bodies will be dealt with in a separate section.

Débridement (*Wound Excision*).—The term débridement has come to be used, perhaps improperly, to describe the excision of devitalized tissues from a fresh wound. This operation must be done thoroughly but with care to avoid vital structures. Débridement is usually not attempted after six hours from

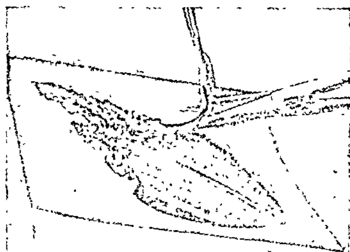


Fig. 8.—Débridement of a fresh traumatic wound. Note how the devitalized tissue is being removed by sharp dissection. (Reid, M. R.: New England J. Med. 215: 753, 1936.)

the time the wound is incurred. Under certain circumstances, however, it may be attempted as late as twenty-four hours after injury.[82]

In describing débridement (Fig. 9), Reid[83] says:

"A dry sponge is tucked into the wound. Clamps are applied about the skin edges for traction. An elliptical incision is made through normal skin about ¼ inch from the edge in large wounds. This is carefully developed into the fat but not through it. As the incision approaches the cavity, blood stains are observed in the tissues and its direction is changed. The clean skin flap is undermined as the edge is held up by small retractors. The undermining continues until the subcutaneous fat joins the muscle fascia. If there is doubt as to where this occurs, the clean wound is protected with moist flat gauze, the field protected with towels, the fluff removed from the dirty wound with a clamp and the cavity inspected. [illegible]

scissors. Areolar tissue can be followed along periosteum, vessels, tendons and nerves. Always protect the field and clean wound with towels and moist gauze, so that in case of contamination the protection can be changed or removed, rather than covered over and allowed to remain as another source of unrecognized contamination.

"Often the dirty wound can be lifted out without a serious break in technique. Severed tendons and compound fractures give the most trouble. In the latter case the dirty cavity

is entered when the broken fragment is encountered. However, there need not be any contamination if one is careful to keep the clean surfaces covered. *The soiled specimen* is clipped free and discarded. The wound is next lengthened in either longitudinal direction until the end of either fragment can be brought out for further débridement. Soiled periosteum stripped from the bone must be sacrificed. It is at this stage when the delayed washing of a wound is most appreciated. Dirt particles are now visible and there is no guesswork

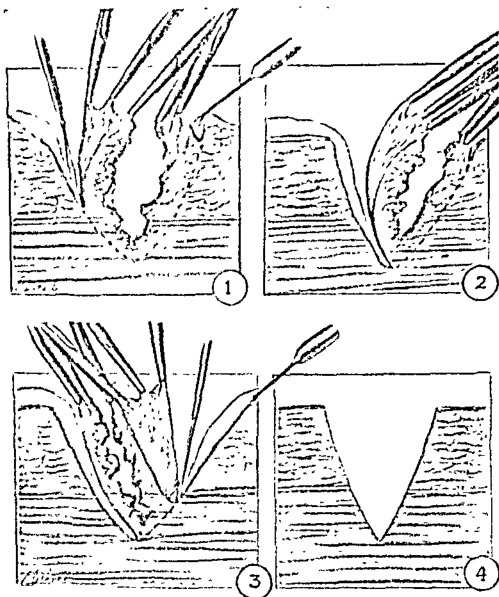


Fig 9.—(1) Hemostats have been applied to the skin edge which is to be excised. The excision has been carried down to the muscle. Fresh pads moistened with saline have been advanced down the clean side of the wound as the incision is deepened. (2) The excision has been completed on one side. Note the protection by the gauze pad. (3) The excision has been nearly completed. (4) The completed excision. The wound is now irrigated copiously with normal salt solution and fresh drapings are applied. (Reid, M. R., and Carter, B. N.: Ann. Surg. 114: 4, 1941.)

in their removal. With an osteotome or thin chisel, a shaving of cortex is started from the clean portion and carried to the end of the soiled fragment. It is picked off with a clamp and discarded. *The entire area of bone denuded of periosteum is cleanly shaved in this manner.* The tip of the fragment is cut off with the same instrument or perhaps a saw or bone cutter. It is not advisable to use a rongeur for any part of the work. Its biting edges always pass through soiled surfaces, besides tending to leave partially detached pieces of bone.

"When débridement of the fragment is completed, it is covered with gauze and returned to the wound. The end of the other fragment is lifted out and similarly treated. After this is done the extreme depths of the wound are systematically given débridement and the cavity is ready for irrigation. Large quantities of warm, but not hot, saline are used. If the fluid is removed by aspiration, one should never use a tube which has been in contact with intra-abdominal or thoracic pus because boiling water under ordinary conditions will not kill spores. The wound is gently rubbed with a gloved finger to detach pieces of loose tissue and blood clots.

"During the operation and before removing the tourniquet, any known open vessels are ligated with fine silk. The cavity is again irrigated after the tourniquet has been released. Inspection is then made for ischemic pieces of tissue which are to be trimmed away. Hemostasis is made secure, but this does not imply the use of unnecessary ligatures. At this stage a few moments of waiting and the use of gentle moist gauze pressure will effectively stop any bleeding points.

"No mechanical fixation of bone fragments in the wound is employed. Tendons and nerves are sutured with silk. The wound is closed with interrupted sutures of silk in the fascia and skin. If the closure is under tension, and it usually is in fracture cases, counter-incisions are made on either side to give relaxation. These defects may be skin grafted or packed with vaseline gauze and allowed to heal by second intention. Viability of skin over the fracture site depends on a closure without tension; the conversion of a compound fracture to a simple one depends on the skin remaining viable and intact. A moist gauze dressing is applied. The fragments are immobilized by skeletal fixation with pins or by cast alone, depending on the type of fracture; but they must be perfectly immobilized. The patient is given the usual prophylactic dose of tetanus and gas bacillus antisera. The dressing is not disturbed for a week or ten days unless there is an unexplained rise in temperature or abnormal pain."[84]

In the removal of devitalized tissue, it is well to be guided by Koch,[85] who says:

"What is devitalized tissue, and how can it be recognized? Skin that is dead white, grayish-white, or purple, that does not bleed when cut nor change in color when gentle pressure is applied with a warm moist pack; muscle that is gray or reddish-gray and that does not contract when gently pinched; tendons and nerves that are discolored with blood, contused, and fragmented; bone that is detached from muscle and periosteum—all these have little or no chance of survival, furnish excellent media for bacterial growth and jeopardize wound healing.

"The importance of excising completely tissue which is devitalized should not lead the surgeon into the error of sacrificing tissue which can be preserved 'It is particularly important that skin should not be sacrificed needlessly, for of all tissues it is the most viable and most necessary' (Lancet 2: 46, 1940). The needless sacrifice of bone fragments

excised."

Since World War I there has been an increasing interest in the primary surgical treatment of wounds of the soft parts. In 1927 Bohler reported favorable results in 2,000 injuries of the fingers and hands. Felsenreich[86] has reported the result in about 2,000 accurately observed injuries treated at the Vienna accident station from 1927 to 1929. The records include cut, lacerated, and bruised and lacerated wounds (the latter being 70 per cent of all cases), without complications from bones, joints, tendons and nerves. As a matter of routine, all wounds not more than twenty-four hours old were surgically treated, regardless of the degree of soiling.

The technic was as follows: The operative field was carefully shaved, no matter how trivial the wound; then superficially cleaned with benzol alcohol and painted with 5 per cent tincture of iodine. After induction of local or regional anesthesia with a 0.5 or 1 per cent novocain solution with adrenalin, the field was cleaned thoroughly with benzol and alcohol and extensively painted with iodine. If the wound was very dirty, the margins were mechanically cleaned with scissors, scalpel and pincers. Then the operative field was blocked out with sterile material, and, with new instruments, the wound excision

was performed, the skin being spared as much as possible. The sparing of the skin for a primary covering of the wound is very important because, as Bier says, the tissue regenerates much better under a protective skin, even if the scab should become necrotic. Before it has sloughed off there is ample time for regeneration. It is then easy to make a secondary transplantation. Primary transplantation is unfavorable unless joints, tendons or other important structures must be covered. In the majority of cases it has been possible to approximate the lips of the wound without much stretching, eventually by displacement of flaps or lateral mobilization of the margins. Dehiscence of wounds must by all means be avoided, because they are bound to cause secondary infection. However, a quadrangular relieving suture far away from the lips of the wound has often proved favorable. The wounds were always sutured with very fine silk.

The subcutaneous bursae mucosae were always removed. If left at the bottom of a wound, they not only cause tedious fistulas with aseptic secretions but are often infected. Their extirpation does not impair the functional result.

Hansen[87] treated 1,000 wounds by primary excision and suture with favorable results.

Dimtza and Gutscher[88] studied 332 contaminated wounds and found the following bacteria: staphylococci alone in 108 cases and mixed with streptococci and colon bacilli in 59; streptococci alone in 31 cases and mixed with staphylococci and colon bacilli in 62; colon bacilli alone in 10 cases and mixed with staphylococci and streptococci in 21; and Fraenkel-Welch bacilli in 57 cases. Wounds infected with staphylococci showed a greater tendency to unite primarily than others, but the type of wound was also of importance in the occurrence of primary union. Primary union occurred in 70 per cent of the cases of pure staphylococcic infection and in 50 per cent of those of pure colon bacillus contamination. It was noted particularly that colon bacteria produced suppuration. The high incidence of Fraenkel-Welch infection indicates that the possibility of gas gangrene [illegible]

of infection with such bacteria, clinical symptoms occurred in only 15 per cent.

Sulfonamides in Fresh Wounds (See also the sections on sulfonamides under Infected Wounds and Wound Healing).—Despite the observations of many workers[43] that the introduction of powdered sulfanilamide or its derivatives does not cause serious damage to the tissues nor does it appreciably interfere with the healing of these wounds, the latest careful studies indicate otherwise. In 1945 Meleney[89] reported on the study and analysis of 2191 patients with civilian accidental wounds of the soft parts, compound fractures and burns in an effort to appraise the value of the use of sulfonamides as preventives Meleney says:

"The use of the sulfonamides as employed in these cases either systemically alone or locally alone, or combined, has not materially reduced the incidence or the severity of local infections in the wounds or burns nor have they delayed the development of infection nor have they eliminated the pathogenic organisms from the wounds. It seems likely, however, that they have minimized the spread of the local infection into the general circulation and have therefore cut down the incidence of septicemia and death. This has been accomplished by systemic drug therapy when infection developed in the controls, as readily as when the drugs have been used either locally or generally as prophylactic agents and employing them only as therapeutic agents after infection has developed. Omitting the routine early use of these drugs would avoid a great waste of material and many toxic reactions. However, if this is done in a rush of military hospital work, the onset of infection might be over-

looked and septicemia might be established before the drugs could be effectively administered.

"It was hoped that it would be possible to demonstrate by statistical methods that the sulfonamides were capable of materially reducing the incidence of infection in wounds treated under the conditions to be found in a number of good civilian hospitals. In fact, it was not beyond the hope of certain individuals that they would be able to do this in spite of certain compromises with surgical principles such as incomplete removal of devitalized tissue and gross contamination—such as might be necessary under the stress of military conditions or when careless ward dressings are done without due regard to the possibilities of secondary wound contamination from the hands or from the nose and throats of the attendants. But such was not the case. Our carefully analyzed figures show that when the local conditions favored infection, the controls on the whole did better than the drug treated cases. These are precisely the conditions in which it was hoped that the drugs might be of value. This tends to lend weight to the belief that the presence of devitalized or damaged tissue in some way inhibits the bacteriostatic action of the sulfonamides. . . .

"All of the results seem to indicate that the main dependence of the surgeon in the prevention of infection both in civilian accidental wounds and in the war wounds must be placed upon the well known principles of the surgical care of contaminated wounds—namely the removal of the devitalized tissue and the contamination and the rapid restoration of the normal physiology of the part involved. The use of the sulfonamides can in no measure make up for this."

Overton[90] made a study of 603 open wounds. In 317 in which sulfonamides were implanted locally, the incidence of infections was 1.26 per cent. In 286 wounds in which no sulfonamides were used, there was infection in 1.39 per cent. From an experimental study, Zintel[91] concludes, in part, that "sulfanilamide in amounts equivalent to one gram per ten square inches of wound surface does not interfere with normal wound healing. Microcrystalline sulfathiazole (particle size five to six microns) implanted locally in wounds, produces wounds with a decreased tensile strength at eight days, but the tensile strength of these wounds is normal at the end of 12 days. Macrocrystalline sulfathiazole, the commonly used form of sulfathiazole, causes a delay in wound healing which is apparent even at the end of 12 days." Posch et al.[92] say: "From a study of excised biopsy specimens, it is evident that sulfanilamide and sulfathiazole act as irritants to the dermis and the subcutis. In addition, they may produce focal areas of necrosis and marked leucocytic response in the adjacent tissues. However, the deleterious effects are short-lived and are not evident in wounds 7 to 10 days old. Subsequent healing is prompt and within normal limits."

Of interest are the comments of Holman,[93] who says in part: "In the management of contaminated wounds and potentially contaminated wounds a mixture of equal parts of sulfanilamide and sulfathiazole powder or crystals is applied in generous amounts to every pocket and crevice of the wound at the earliest possible moment whether on the field of battle, at first aid stations, or in the emergency rooms of our hospitals At the first dressing or at the first inspection of the wound, every effort should be made to get the drug in contact with *all* raw surfaces. The earlier the drug can be applied after bacterial contamination, the more effective will be the inhibition of bacterial growth.

"The local application of the drug should be repeated again at operation when a débridement or excision is performed. When operating in a dirty or potentially contaminated wound as during a débridement, or in the closure of a colostomy, the drug mixture should be applied at successive stages as the operation proceeds and as freshly incised areas are exposed in the operative field, endeavoring to impregnate these raw areas simultaneously with or even before their contamination by bacterial organisms." Howes[94] reports that "thirty contaminated wounds have been successfully sutured after a mixture of sulfamylon

(homosulfanilamide, marfanil, mesudin) and streptomycin was used as a subcutaneous antiseptic."

Lockwood[95] recommends that not over 15 Gm. of sulfanilamide be applied to wounds in any one patient, because of possible toxic effects from rapid absorption. Whipple[96] advises the use of not more than 10 Gm. of crystalline sulfanilamide in any one wound and not more than 20 Gm. in all wounds of a single patient. Lewis[97] believes that the powder should be rubbed over the wound surface with the fingers, just enough being used to obtain an even coating. Most authorities believe that the wound should be lightly frosted by means of a shaker or atomizer. The powder should be used in the fresh wound and after débridement also.

After careful study Osgood[98] says "of the drugs now available for local therapy, powdered sulfathiazole seems to be the drug of choice, since it is more effective than sulfapyridine or sulfadiazine and less toxic to cells in the concentrations attained than is sulfanilamide." McSwain and Glenn[99] studied the results of implantation of sulfadiazine into experimental wounds inoculated with a culture of beta hemolytic streptococcus and concluded that it resulted in: "(1) decreased mortality rate; (2) increased survival time; (3) lower percentage of positive blood cultures; (4) slightly lower percentage of positive wound cultures; (5) apparent improvement in wound healing." They add that the favorable features enumerated "were evidently due to the local action of the drug since no more than a faint trace was detectable in the blood."

The local use of sulfonamides in wounds is discussed by Hanrahan:[100] "Sulfanilamide is the most soluble and sulfathiazole is the least. Early local concentration is therefore greater with the former although it is absorbed more rapidly. Sulfanilamide is effective against the streptococcus and sulfathiazole against the staphylococcus. Sulfadiazine has a wider range of bacteriostasis and is effective also against the streptococcus and slightly superior than sulfathiazole against the staphylococcus. Its solubility is less than that of sulfanilamide and sulfathiazole. The concentration and penetration of these drugs when implanted locally appears to parallel their solubility, while the duration of such concentration varies inversely with the solubility. Accordingly, penetration throughout a wound is quickest with sulfanilamide, moderate with sulfathiazole and slow but persistent with sulfadiazine."

Chambers and his associates[101] believe that "sulfathiazole is superior to sulfanilamide powder as a local application in traumatic wounds and infections because it is effective against a wider range of the organisms usually found and because it exerts its effective action over a longer period of time." These authors employed microcrystals of sulfathiazole.

It is to be remembered that necrotic tissue and pus contain sulfonamide inhibitors.[102] Casten and his associates[103] have shown that "procaine will inhibit the bacteriostatic activity of sulfathiazole in wounds inoculated at the time of trauma with a suspension of staphylococcus aureus."* *Propamidine* has received the endorsement of Thrower and Valentine[104] and of Kohn and his associates.[105]

Sulfonamides employed locally in wounds must be sterile. The U. S. Food and Drug Administration[106] found various pathogenic organisms in unsterilized sulfonamide powders of commercial grade. Full details of the methods of sterilization of sulfonamides are given by McCartney and Cruickshank.[107] Sterile sulfonamides can be obtained commercially in paper envelopes.[108]

Many favorable reports have been published on the *oral or parenteral use of the sulfonamides in fresh wounds.*[109] Altemeier[110] says: "Although the incidence of local infection has not been decreased, the occurrence of spreading infection, of septicemia or of death due to infection is extremely low. The evidence is therefore strongly indicative that general sulfadiazine therapy minimizes invasive infection. For this reason it is our practice to administer systemic sulfadiazine therapy at the earliest opportunity and to continue it

* Bacteriostatic action of amidines, unlike the sulfonamides, is not inhibited by the peptones and other constituents of pus and tissue fluids in wounds.

postoperatively. The dose is adjusted to the weight of the individual patient and a blood level between 6 and 10 mg. per hundred cubic centimeters is maintained for at least ten days. Daily sulfadiazine blood level determinations, red and white blood cell counts and urinalysis are used to control the administration of this drug." Lee[111] reports that after "2 Gm. of sulfadiazine was administered to 25,000 persons, 0.50 per cent showed reactions, 0.036 per cent showed serious reactions and 3 patients were critically ill." Hoerr[112] analyzed a consecutive series of 200 secondary closures of soft tissue war wounds from the standpoint of the prophylactic effect of sulfadiazine administered orally at the time of closure. The evidence presented favors the view that sulfadiazine so employed is beneficial, and that it reduces the incidence of postclosure infection and delayed healing." Lyons[113] says: "The efficacy of *systemically administered* sulfonamides in the therapy of impending streptococcal infection is clearly established." He[114] also says: "Specific chemotherapy, given by the systemic route, is a proper adjuvant to an expanded surgical program for more effective wound management." Sulfathiazole or sulfanilamide may be taken in a dose of 6 Gm. immediately after a wound is sustained, followed thereafter by 1 Gm. every four hours. Sulfanilamide may be given as a hypodermoclysis, as an 0.8 per cent solution in normal saline. (See section on the Surgical Intern for other parenteral administration.)

Zinc Peroxide.—Meleney[115] recommends the use of zinc peroxide in fresh traumatic wounds in which no attempt at closure is made. He says:

> "Traumatic wounds are always contaminated by organisms, and become infected unless the cases are seen early, débrided thoroughly, and treated antiseptically.
>
> "The most virulent contaminating organisms are the hemolytic streptococci, the gas gangrene clostridia, and the non-spore-forming anaerobic cocci and gram-negative bacilli, which are susceptible, both in the test tube and in the wound, to zinc peroxide.
>
> "The prophylactic use of zinc peroxide in the immediate treatment of traumatic wounds will in most cases prevent infection with these organisms."

Antiseptics.—Antiseptics have little part in the treatment of fresh wounds. Their chief usefulness lies in the preoperative preparation of the skin and the sterilization of instruments, which will be discussed in a later section. The value of Dakin's solution, zinc peroxide and a few other antiseptics in the treatment of infected wounds will be taken up separately in this chapter. For abrasions, sterile vaselin may be applied after the soap and water cleansing *So-called "surgical dusting powders" should never be used on a discharging wound, where they combine with the exudate to form an occlusive crust.*[116]

Closure of Wounds.—The type of wound which requires suture varies with the judgment of the attending surgeon. If the wound can be satisfactorily cleansed, closure is the best protection against bacteria and the best agent to promote quick healing Many small wounds have been closed with sutures which would have healed equally well without. In some cases the sutures may be placed and tightened up later when conditions warrant. Scalp wounds in particular seem to be the pet subject for the introduction of sutures. Wounds of the scalp extending down to the periosteum and having a length up to 1½ inches will heal rapidly and cleanly if, after antiseptic preparation, a firm pad is bandaged in place. Many wounds of the extremities of a length up to 2 or 3 inches will heal satisfactorily with a pressure pad and bandage. There is no question, however, that in wounds on the face, where the minimizing of scar formation is the chief consideration and where it is difficult to put the parts

at rest, careful suture with early removal is indicated, even for very small wounds. The accurate closure of a wound, moreover, is an excellent protection against invasion by pathogenic bacteria.

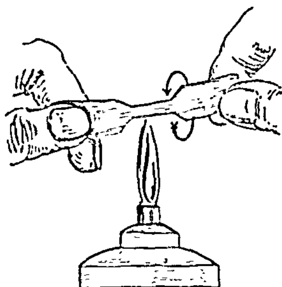


Fig. 10.—Adhesive strip for approximation of wound edges. The strip is cut out in a dumb-bell shape so that the narrow central portion does not exceed ⅛ inch in width. It is flamed on both sides over a Bunsen burner or spirit lamp. (A match or cigaret lighter will do.)

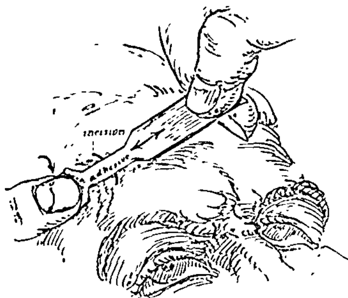


Fig. 11.—Application of "dumb-bell" adhesive strip to a small wound. The strip has been flamed on both sides. It is fixed on one side first and is then drawn toward the other, thus approximating the wound edges. The central portion should be somewhat smaller than is shown in the figure.

A word of particular warning must be spoken of the increased risk incident to the closure of wounds which communicate with bursae or tendon sheaths. A common place for such a wound is over the olecranon bursa. A case in point is that of a man who had a 1 inch wound of the olecranon bursa neatly sutured. Forty-eight hours later he had a virulent streptococcic infection which involved the entire forearm, requiring subsequently many incisions of the

forearm and eight or ten weeks of morbidity before complete recovery was effected. It would have been far better to have left this wound wide open. The chief factor is probably that of sterilization rather than the anatomic structure. Bursae are difficult to sterilize once they have been contaminated. However, in some cases in which the wound has been thoroughly irrigated with saline solution, closure is permissible. In these cases the patient should be watched with particular care, and at the first sign of local infection or systemic disturbance the stitches should be removed and the wound opened freely. Moreover, it is advisable not to close a wound for the purpose of controlling hemorrhage from its depths. A large hematoma invariably will result, and the danger of infection and the length of disability are greatly increased. A wound should never be closed until bleeding is accurately controlled.

Many small wounds may be closed very satisfactorily by the use of adhesive plaster. It is important to cut the pieces of adhesive plaster in a somewhat dumb-bell shape (Fig. 10), so that a very small width of plaster crosses the wound and yet a large surface of plaster is applied to the skin to give adequate

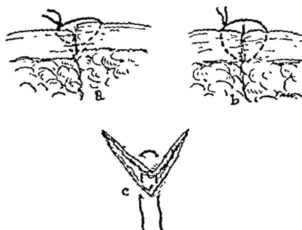


Fig. 12.—Introduction of wound sutures: *a*. Improper method, close coaptation of skin edges not effected. *b*, Correct method of placing sutures. *c*, Suture of an angular wound. (After Moorhead.)

traction (Fig. 11). The adhesive plaster at the "handle" of the dumb-bell should be cut out, *not folded over*. If the width of the adhesive plaster crossing the wound is narrow and applied at several points, ample exit for the wound secretion is provided, and infection is very unlikely. A wound of the forehead, 5 inches in length, was perfectly coapted by adhesive plaster bridges, with no infection and a minimum amount of scar.

The indications for suture of a wound are, first, the necessity for very accurate approximation, as on the face, where even wounds of very small size may require suture, and, second, in wounds of large size, the need for prevention of infection and acceleration of healing. Once the decision to suture has been reached, the proper instruments and material must be selected. For wounds on the face, small curved, sharp cutting needles, with a radius of $\frac{1}{4}$ to $\frac{1}{2}$ inch, should be employed. A small needle holder and an extremely small tissue forceps with teeth, such as is used in ophthalmologic work, are of value. Very fine suture material should be used; for this purpose, the so-called "dermal suture," or very fine silk, preferably on fused needles, is the best. Horsehair is useful.

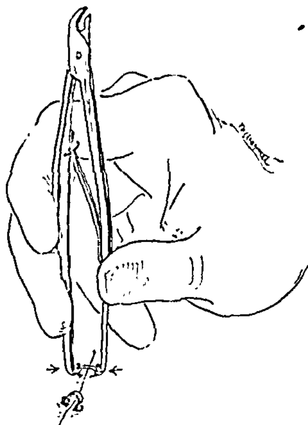


Fig. 13.—Wound closure with Michel clips. The wound edges are approximated with two mouse-toothed forceps, or the incision is stretched lengthwise with two Allis clamps. The clips are introduced with the special clip holder. The skin edges must not be inverted. The clips will go in more readily if they are slightly curved before they are compressed.

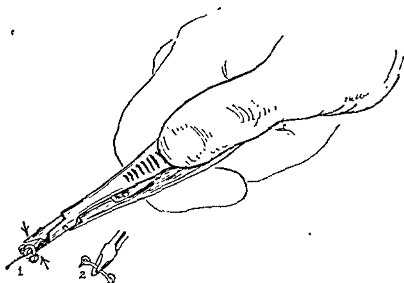


Fig. 14.—Removal of Michel clips. When the clip remover is closed, the prongs of the clip are spread apart, and the clip is painlessly removed.

Preston[117] recommends skin closure with stainless steel wire with an interrupted, loose, small bite stitch. Botsford[118] has shown the superiority of silk over catgut as a skin suture.

The sutures should be accurately placed (Fig. 12), so that equal bites are taken on the two sides of the wound. The sutures should not be tied too tightly, and great care should be taken to see that the skin edges are not inverted. On the face, half of the sutures may be removed at the end of twenty-four hours and the other half at the end of forty-eight, unless there is special reason to the contrary. These are usually left unprotected by a dressing if it is possible to sponge them with boric solution every fifteen minutes for the first three hours and at longer intervals thereafter. Where there is strain on the suture line, as over the prominences of joints, it will be advisable to introduce tension sutures to take the strain off the wound suture line. One should not hesitate to remove a suture and reinsert it if it is felt that the coaptation is not accurate. In small wounds, sutures which do not penetrate the entire thickness of the skin will leave a minimum amount of scar.

The use of Michel clips, as advocated by many, has a distinct advantage. With the proper instrument for introducing them (Fig. 13) they may be applied with less pain than is necessary in the taking of stitches, and with the aid of the clip remover (Fig. 14) they can be removed almost painlessly. The Wachenfeldt clip may be taken out without a special clip remover, *i. e.*, with an ordinary hemostat. However, the placing of clips requires a certain amount of skill and perfect quiet on the part of the patient. For this reason they are rather unsuitable for a nervous, crying child. There is also some disadvantage if the dressing drags against the projecting clips.

After dressing the sutured wound with a small quantity of scarlet red impregnated gauze, Gallagher[119] uses the following method to relieve tension at the skin edges: "Using collodion as glue, sterile strips of bandage one-eighth inch wide are fastened to the skin on alternate sides crossing the wound, close to the gauze. Using a hand dryer to speed drying, the dressing surgeon pulls on a strip on one side with his left hand while an assistant pulls on the next strip on the opposite with sufficient force to take all tension from the suture line. All strips are glued into place."

Young and Favata[120] report on the "suture" of wounds by plasma-thrombin adhesion. They say: "Adherence of wound edges or surfaces can be readily accomplished by the use of plasma and purified thrombin. The fibrin fixation artificially produced in this way has less tensile strength than ordinary suture material; for this reason use of plasma-thrombin adhesion of wounds should be limited to those in which tension does not exist. Plasma-thrombin adhesion has been found useful as the sole fixation (1) for traumatic lacerations, (2) as a skin closure where a particularly fine scar is desired, (3) as a method of producing adhesion between the flaps and the chest wall in radical mastectomy and (4) as an adjunct in free skin graft. No untoward results have been observed in 69 cases in which plasma-thrombin adhesion of wounds has been used."

In some cases a wound may be so old that it may no longer be regarded simply as a contaminated wound but must be considered as an infected wound. In such cases *delayed closure* is indicated. The steps up to the closure are the same as have been previously described. Instead of suturing, Reid and Carter[121] loosely pack the wound in all its recesses with moist saline gauze, which is then covered with gutta-percha to keep it moist. The part is immobilized for from twenty-four to forty-eight hours. If the wound then appears clean and is not inflamed, it is closed. Coller and Valk[122] pack the wound for

twenty-four hours with flavine gauze (in cases of abdominal wounds contaminated by colon contents).

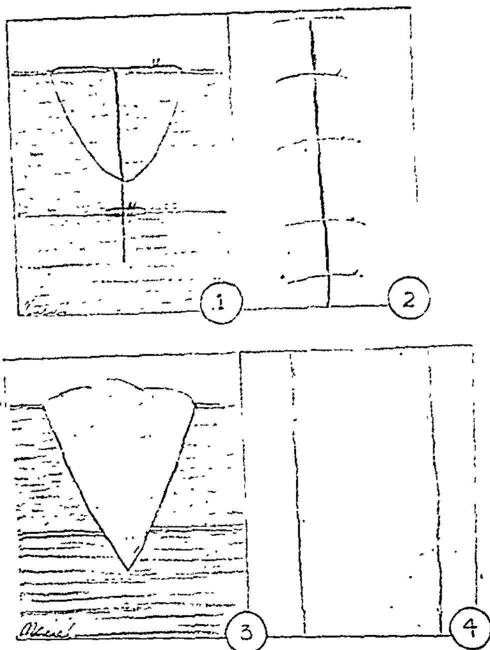


Fig. 15.—(1) and (2): Primary closure of the wound. The fascia over the muscle has been sutured with silk. The skin sutures have been so placed as to leave as little dead space as possible. These sutures are placed rather far apart and tied loosely. (3) and (4): If primary closure is not feasible, the wound is packed loosely with gauze. A plaster encasement is then snugly applied so as to completely immobilize the part. (From Reid, M. R., and Carter, B. N.: Ann. Surg. 114: 4, 1941.)

When there has been an *avulsion of skin*, the problem of closure is more involved. Koch[85] says:

"With avulsion injuries and loss of covering tissues the hours immediately following injury are of vital importance, for unless one seizes the opportunity to convert the contaminated wound into a clean one and closes it within a few hours of the time of injury the possibility of securing the most favorable result is irretrievably lost. A razor graft of

intermediate thickness, a graft of whole thickness, a graft of whole thickness skin, a sliding flap or a flap from a distance may meet the indication in any particular case; the important consideration is that such a procedure, if carefully carried out, has every chance of success during the early hours following injury, but if infection develops over an extensive raw surface, an almost inevitable occurrence if the wound is treated expectantly, the chance of *securing a satisfactory result is greatly diminished and the opportunity to accomplish it* long deferred"

Bancroft[123] has been favorably impressed by the teachings of Farmer[124] in regard to *avulsed skin flaps Referring to Farmer, Bancroft says:*

"He states that when the skin and subcutaneous fat are avulsed, thrombosis of the venous and lymphatic vessels is produced by the trauma. On the other hand, the arterial vessels are not as easily injured, and they continue to pump blood into the traumatized zone. When the pressure of the incoming blood overcomes the normal tissue pressure, necrosis occurs as the smaller arteries begin to thrombose. . . .

"If Farmer's theory is true, his method of treatment is a real advance in the handling of avulsed wounds. He believes in the excision of all of the avulsed skin, for he says that if a portion of the skin is left attached, the arteries will continue to pump blood into the skin and subcutaneous tissue and gangrene will result. When the skin has been removed, *the assistant carefully débr[illegible] the underlying structures, removing all dead or traumatized* tissue. Farmer advises the [illegible] area with aseptic rather than antiseptic fluids. Thus soap and wat[illegible] choice. The surgeon removes the avulsed skin. [illegible] or by cutting with curved scissors well into [illegible] *débridement of the deeper structures* with complete hemostasis [illegible] taneous fat, the skin is then sutured accurately into the defect from which it was [illegible]. To prevent dead spaces, quilting sutures are used in addition to the circumferential sutures, and the graft is perforated with numerous small stab wounds. The primary dressing is of normal saline. Firm pressure is obtained by bandaging, and a plaster encasement insures immobility The dressing is changed in 10 to 14 days unless there is a special indication for an earlier examination."

In this connection the case reported by Jayes[125] is of interest:

A horse bit off a 7 x 3½ in. piece of skin from the thigh of a boy, 13. The mother immediately replaced the piece on the leg and bandaged the limb with boracic lint. At the hospital, the piece of skin was washed in warm saline; it appeared to be in perfect condition. It was pinned on a board and all subcutaneous fat dissected off its deep surface, thus converting the avulsed tissue into a full-thickness skin graft. The wound was washed, sprayed with sulfanilamide powder and the graft sewed *in position with fine silk sutures* Exit for blood or serum was supplied by fine slits. Fixation of the graft was done by soaking a roll of wool in flavine and paraffin emulsion and teasing it out into fine layers; these were applied to the graft and built up to form a thick, even pad. Gauze and wool and a crepe bandage were applied and the knee immobilized. Convalescence was uneventful. The seventh day the bandage was removed. Appearance of the graft was satisfactory and the bandage was reapplied. The tenth day about 80 per cent of the graft had taken, the small loss being at the site of original abrasion. This area also healed.[126]

Drainage of Wounds.—A recently incurred wound of the scalp, face or [illegible] has been adequately cleansed and sterilized and in which [illegible] need not be drained. However, in particularly dirty wounds [illegible]sive undermining of skin flaps, or when a continuous oozing of blood cannot be controlled, drainage may be considered. If circumstances permit, however, practically every dirty wound can be converted into a clean one with soap and water cleansing and the excision of devitalized tissue. For a small wound, so far as drainage is concerned, Penrose tubing will serve admirably. In larger wounds, for example, where a flap of skin has been partially avulsed, drainage may be effected by using one-half of a rubber tube drain ½ inch in diameter. The wound should not be tightly packed with gauze. Where the flap is greatly undermined it is advisable to make a stab wound and draw this drain through the flap. The present

tendency is toward the less frequent employment of drainage in fresh wounds which have been properly cleansed mechanically and chemically.

Dressing of Wounds (See section on Surgical Dressings).—The purpose of the application of a dressing to a wound is to prevent the invasion of pathogenic bacteria, to furnish a sterile absorbent for the normal wound secretion and to exert pressure. In wounds of the face, particularly those in the vicinity of the mouth and the nostrils, where mucous secretion may readily contaminate the dressings or where food or fluids may inadvertently be spilled upon the dressings, the open air treatment is to be preferred. In this method no dressings whatsoever are placed upon the wounds, but the nurse or parent in charge is instructed to sponge the wound gently with a cotton applicator saturated in boric solution at intervals of fifteen minutes during the first six or eight hours. This procedure will remove the small amount of excess secre-

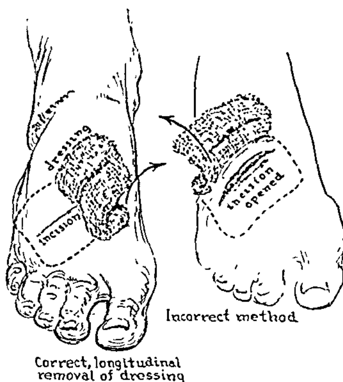


Fig. 16.—The adherent dressing should be removed in the direction of the wound axis. If the dressing is pulled across an unsutured wound, the latter may be torn open.

tion and at the same time will apply a mild antiseptic to the wound surface. If the open air treatment is not to be used and a dressing must be applied, gauze is far more suitable than any other material. Cotton should never be used in direct contact with the wound, as its fibers become firmly attached to the scab and are almost irremovable. A dry gauze dressing is generally the dressing of choice. When the gauze is removed at the first dressing, which generally is on the sixth to tenth day, it is important to remove it in a direction parallel to the wound (Fig. 16). Ill advised traction on gauze over a wound at right angles to the wound not infrequently will open it. When there is particular necessity for the nonadherence of the dressing, as in abrasions, sterile white vaselin may safely be used. White vaselin is preferable to medicated vaselin, particularly to carbolated vaselin, which never should be used. Moist boric dressings can often be employed to advantage on a freshly sutured clean

wound. De Motte,[127] following an experience with 12,000 wounds, recommends moistening the dressing every two hours with hot water. The gauze dressing is preferably held in place with elastic adhesive or a bandage, which has the advantage of furnishing a moderate degree of pressure to the healing wound and is free from the disadvantage which adhesive has of painful removal. In small wounds, however, as on the forehead, where a bandage is objected to on the score of appearance, the gauze should be fastened to the skin with elastic adhesive, ordinary adhesive plaster or "scotch tape." Care should be taken that this adhesive plaster is not placed in the hair unless absolutely necessary. For wounds of the scalp a head bandage is preferable to adhesive plaster. A proprietary preparation called "band-aid" is useful. It consists of a small strip of adhesive tape with a small sterile pad of gauze already applied to it and is an extremely quick and convenient dressing. (See section on removal of sutures.)

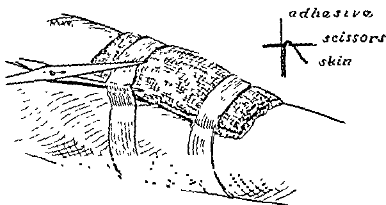


Fig. 17.—Removal of dressing without pulling off the adhesive plaster. Care must be taken that the skin is not pulled up with the adhesive plaster, in which event it may be clipped with scissors (see insert).

If a wound has to be repeatedly dressed, it is greatly to the patient's comfort not to remove the adhesive plaster at each dressing, but to cut through it at the junction of the gauze with the place where the adhesive plaster is attached to the skin. In cutting the adhesive strip at this point, extreme care must be taken not to snip the skin itself, which is lifted up as traction is made upon the adhesive strip (Fig. 17). Kelly[128] has described an ingenious method of fastening hooks (of the "hook-and-eye" variety) to adhesive tape for lacing over wounds. Rubber bands may be used for the lacers. Adhesive strips with taped ends are useful. (See the section on Surgical Dressings, Chapter XXV.)

Rest.—Wounds will heal more rapidly if they are put at rest. A wound of a finger which is subjected to frequent motion should be held quiet with a small tongue depressor splint. Wounds of the skin in the neighborhood of joints are best treated by some method of immobilization of the joint. It is generally unnecessary to splint the extremity for a wound of this type, but it is advisable to have the patient in bed for several days. For extensive wounds of the arm and wrist, the use of a sling is indicated.

INFECTED WOUNDS

Open Infected Wounds.—(See also Infections and Gangrene.) All wounds are contaminated at the time of the injury. Infection develops at a variable

period (from six to ten hours) afterward. The usual infecting organisms are the hemolytic and nonhemolytic staphylococcus and streptococcus, the colon bacillus and proteolytic and anaerobic organisms. When the infected wound is first seen it may be small, with an area of induration and inflammation about it; or it may be wide open, with a considerable purulent discharge.

Sumner Koch[129] emphasizes the five principles involved in the care of infected wounds. He says:

> "One must accomplish: 1. *Localization of the infection.* 2. *Drainage when the infection is localized.* 3. *Sterilization of the infected area.* 4. *Covering of the raw surface,* if loss of superficial tissue has taken place; or obliteration of the cavity if the infection resulted in abscess formation. 5. *Restoration of function.*"

To these principles might well be added *systemic and local chemotherapy and antibiotic therapy.*

To aid in the localization of the infection, the affected part must be placed at absolute rest, hyperemia must be augmented and the circulation must be aided by elevation.

Rest prevents pain and tends to prevent the spread of infection. Rest of an extremity on pillows or support of an arm in a sling is usually sufficient. Wangensteen[130] places great stress upon the value of strict immobilization and elevation. For acute infections of the extremities, such as phlegmons, lymphangitis and phlebitis, the affected part is placed in a windowed plaster cast and markedly elevated. By this method, he contends, a single short incision or none at all may suffice. Koch[129] says:

> "[illegible]
> to maintain at the highest possible activity the metabolism of the tissues involved. In increasing the blood supply to an infected area nothing is more effective than the application of warm, moist dressings. Elevation of the affected part, by bringing the assistance of gravity to the venous circulation, assists in the elimination of waste products and in preventing passive congestion at the site of injury. One cannot dismiss the subject of warm, moist dressings, however, with the statement that they afford the most effective method of producing a local hyperemia. To be continuously effective wet dressings must be *kept warm,* and at the same time the patient must not be required to lie on wet sheets and a wet bed. A common method of applying warm, moist dressings consists in wringing out hot cloths or pads in a hand roller and applying them with bare fingers to the area to be covered. Such a method is wasteful of dressings; it furnishes frequent opportunities for secondary contamination of the wound; the dressings remain warm for only a brief interval. If they [illegible]
>
> [illegible] blood supply, and lowers the metabolism of the affected area. All three factors favor the development of infection. [illegible]
> the lowered vitality o[illegible]
> a harmful effect in th[illegible]
>
> "We believe as a r[illegible]
> of constant and unvarying heat if one wishes to keep a moist dressing warm. This can be accomplished by [illegible]

the dressings are completely removed and replaced, with the same careful attention to aseptic technique as when they were first applied. The inclusion of a light, sterilized aluminum splint within the dressings helps to provide the rest which is so important a factor in the successful treatment.

"Continuous warm, moist dressings should not be applied indefinitely. If the part becomes edematous and water-logged and the skin becomes soft and macerated, persistence in such treatment hinders instead of hastens healing by reason of the passive congestion produced, the subsequent strangulation of tissue cells, and the resulting necrosis. To prevent such a complication after localization is well under way one can substitute intermittent application of moist heat for continuous application, and between treatments

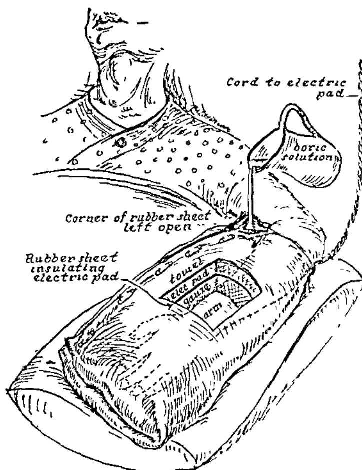


Fig. 18—The technic of hot boric acid fomentations. An abundant quantity of gauze [illegible] t. The [illegible] l. The [illegible] all a towel is pinned to hold the pad in place. As the solution evaporates from the gauze, more is added at a corner. In the absence of an electric pad a hot water bottle or frequent changes of hot gauze will be necessary.

dry the part thoroughly and so diminish congestion. If the affected part is the hand or the upper extremity it is soaked in a sterile arm bath one or twice daily. At the end of fifteen or twent [illegible] a half hour under an elect [illegible] overed with dry dressings, [illegible] the affected [illegible] tissues and prevent edema. After the infection is under control gentle movement while the affected part is being dried not only aids the venous return but helps to prevent the stiffness

of muscles and joints which develops so rapidly in constantly immobilized limbs in which infection is present."

The heating unit wired in the design of an involute coil which is described by Cooley[131] should prove very useful in maintaining a hot compress at a constant temperature.

The *technic of applying hot boric acid fomentations* is one that is rarely accurately accomplished and one that requires a certain amount of skill on the part of the attendant or on the part of the patient if he cannot be provided with a nurse. If the skin is extremely tender in the neighborhood of the wound, it is occasionally of value to anoint it with a thin layer of sterile vaselin. After this, gauze which has been wrung out in warm, *not hot*, saturated boric acid solution should be copiously applied to the wound. The common error is not

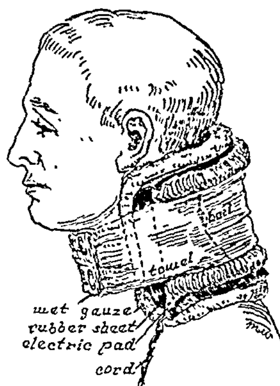


Fig. 19.—Technic of continuous hot boric acid fomentations to the neck with employment of an electric pad.

to apply sufficient gauze or absorbing material. The infected area should be enveloped for at least 5 or 6 inches beyond its margin with a thickness of overlying gauze of at least 1 inch or, preferably, 2 inches. This large bulk of dressing insures the maintenance of a continuous hypertonic pack. The action of saturated boric acid solution is but mildly hypertonic, and when a more powerful action is desired, magnesium sulfate is recommended. Boric acid solution, salt solution or even plain sterile water may be used, according to Kanavel and Koch.[132] After the gauze has been bandaged neatly in place, a rubber sheet, oiled silk or some other impervious material is placed over the moist dressings. An electric pad (or pads) is then applied to this waterproof surface. The patient is cautioned not to allow the electric pad to become wet, because of the risk of short-circuiting the pad. Over the top of the electric pad is placed a binder or bath towel, which is snugly pinned so as to hold the

electric pad in position (Fig. 18). The pad is then connected with a light socket and turned on at low or medium heat, as suits the patient. If the patient is ambulatory, for instance, with a carbuncle on the neck, he can walk about the house and "plug in" where most convenient for him (Fig. 19). From time to time, as the solution becomes evaporated because of the heat of the pad, it should be replenished. One end of the dressing should be opened cautiously and more solution poured in from a sterile receptacle. By this method the patient may with comfort sleep through the night, and a continuous moist hot hypertonic treatment can be carried out without interruption. Kanavel and Koch[132] do not employ the electric pad in the technic of treatment with continuous warm moist dressings. They apply a large sterile dressing to the affected part and moisten it, but not saturate it, with warm boric acid or other solution. Over this a powerful light is suspended which is covered with a cone-shaped hood of canvas so as to concentrate the heat over the affected part and prevent the access of draughts of cold air. Every two hours the outside covering of the dressing is opened for moistening and the light replaced. They also employ an electric oven or baker, which is placed like a cradle over the affected part.

To maintain heat in moist compresses, the baking lamp described by Pearse[133] is useful. It is attached to the bed by a specially designed clamp. The warm fomentations must not be kept up indefinitely. If the part becomes water logged and the skin macerated, the treatment should be made intermittent, alternating with periods of drying, or several wet and dry treatments may be given daily. The principal benefit of wet dressings is thought by Taylor[134] to be due to the poulticing action. Kanavel and Koch[132] emphasize the importance of maintaining an extremity in the position of function during the period of forced immobilization with wet dressings or rest. If the hand is being treated, the wrist should be dorsiflexed, the fingers semiflexed and the thumb abducted from the hand and facing the fingers. In the lower extremity, foot drop, fixation of the knee, hip in flexion and external rotation of the leg should be avoided.

The pliofilm mitt described by Stryker and Grindon[135] is useful for enclosing wet dressings.*

Specific antitoxins should be given when indicated. Blood transfusions often are valuable. In severe infections, rest in bed is advisable. The fluid intake must be abundant. Sulfonamides will be useful in many infections. (See sections on sulfonamides.)

If the wound is not entirely wide open and an accumulation of pus takes place in any part of it, drainage will be indicated. But far more harm is done by premature incision than by delayed incision. It is a sage rule to wait a little longer than seems necessary. Only the sharpest scalpel is used in incising, and general anesthesia is preferred. The use of warm moist dressings is continued for a few days after the institution of drainage. Once a drain is removed it should not be replaced, because of the likelihood of reintroducing infection.

Sterilization of the wound area is best accomplished by *soap and water cleanliness*. "To permit macerated epithelium, encrusted wound secretion and coagulated blood to cover skin edges and the area about the wound is to provide favorable conditions for bacterial growth." (Koch.) Sterile instru-

* Pliofilm mitts are made by Goodyear Tire & Rubber Co., Inc. See also "derma-mitts," made by The Progressive Laboratory Specialties Co, 146 Hillside Ave., Jamaica, N. Y.

ments, soap solutions, sterile water irrigations and gauze pledgets are used in the cleansing of the wound. Gloves should be worn by the surgeon in cases of virulent infection to protect his hands. Reid[73] warns that no dressing be used which when removed will cause bleeding of granulation tissue.

A physician's acquaintance with the art of surgery may rather accurately be estimated by the manner in which he changes a dressing. Anyone who grasps in his fingers a pus-soaked dressing may be stamped as grossly inefficient. He endangers himself and the patients entrusted to his care. All infected purulent dressings should be removed with sterile instruments and should be placed in a paper bag or suitable receptacle. The dressing may be adherent to the wound. This annoyance may be greatly mitigated by the previous application to the wound edges of sterile white vaselin or boric acid or mercurochrome ointment. It is extremely important when the dressing is adherent to remove it in such a manner that the traction is parallel to and not across the wound edges. All manipulations about the wound, such as cleansing of the skin, irrigations and applications of antiseptics, should be done with instruments. In the ideal dressing the surgeon's hands never come in contact with the wound or the dressing.

The early removal of necrotic tissue, which is an excellent culture medium for bacterial growth, will hasten wound sterilization. Occasionally the slough may be partially cut off but never if bleeding is caused. Irrigation with Dakin's solution every two or three hours will cause liquefaction of the necrotic material and acceleration of healing.

Koch[129] states: "As sterilization of the wound area takes place the raw surface rapidly assumes a healthier appearance. Wound discharge lessens; granulations become red and healthy. During this period healing can be favored by applying directly over the wound surface gauze of so fine a mesh that granulation tissue cannot grow into it and be torn away with each change of dressing. A second helpful factor, as often emphasized by Blair and his associates, is the application of firm pressure to the raw surface by means of sea sponges bandaged over the outside of the dressing. Such pressure, as many surgeons have demonstrated to their satisfaction, prevents passive congestion of granulation tissue, and by improving the circulation stimulates wound healing. Pale and flabby granulations can be converted into firm and red ones within a week's time by simply adding to cleanly treatment some method of applying pressure over the wound area. If, on the other hand, exuberant granulation tissue is destroyed with silver nitrate or some other caustic, nature's effort at healing is simply thwarted until the damage can be repaired.

"When the raw surface is surgically clean, as evidenced particularly by its healthy appearance and by the absence of bacteria from smears taken from the wound, if larger than a silver quarter it should be covered with a skin graft. Time can be saved, scar-tissue formation lessened, contractures prevented, and the ever present danger of reinfection eliminated by covering such raw surfaces with skin grafts at the earliest possible moment. With extensive raw surfaces, such as are present after burns and crushing injuries, this *consideration is of particular* importance. With care and skillful treatment the average time of convalescence in such cases can be measured in weeks instead of in months."

In regard to restoration of function Koch (*loc. cit.*) lays down the following simple rules:

"1. During the period of enforced immobilization—the stage of acute infection—the part should be immobilized in the position of function, in other words, in that position in which function would be greatest if mobility were impaired or lost. 2. As soon as the stage of acute infection is passed gentle movement two or three times daily through as [illegible]

[illegible] healed, by soaking the affected part in warm water and washing it for fifteen or twenty minutes once or twice daily with a soft wash cloth and soap suds one can provide both an increased blood supply and gentle massage quite as effectively as with considerably

more elaborate and expensive methods of treatment. 5. Active movement, even though limited in extent, constitutes the most helpful form of physical therapy."

From his experience in several thousands of dressings in which glycerin was employed, Lichtenstein[136] has found that when chemically pure glycerin is applied, at or slightly above body temperature, to a suppurative wound, it aids in diminishing the amount of wound exudate. Spreading lymphangitis and tissue swelling may be inhibited or diminished by frequent applications of this substance. Removal and reapplications of dressings impregnated with glycerin are not painful and do not occasion so much discomfort as dressings commonly do in suppurative wounds. Lichtenstein is of the opinion that following the establishment of drainage from infected wounds subsequent to the use of hot wet dressings, glycerin applications are of distinct value in avoiding maceration and the development of superficial infections that commonly follow continuance of hot moist applications.

The studies of Anderson[137] seem to indicate that "the few antiseptics, which decreased the number of surface organisms in wound healing at a normal rate, were ineffective in the presence of tissue necrosis, and exerted no beneficial effect on the rate of wound repair." On the other hand, this worker thinks that none of the agents he studied retarded healing by excessive chemical irritation of tissue cells.

Sulfonamides in Infected Wounds. (See also the section on Sulfonamides in Fresh Wounds.)—The sulfonamides to be chiefly considered in the local treatment of infected wounds are *sulfathiazole*, *sulfanilamide* and *sulfadiazine*. Sulfathiazole is less soluble than sulfanilamide, and its action is therefore more prolonged. As it is more prone to cake if unevenly applied, it must be "evenly frosted" on the wound surface. Of the two drugs, sulfathiazole is probably preferable in the local treatment of wounds.

Meleney[138] has described to the author a method of using sulfonamides in infected wounds which has proved extremely valuable on repeated trial. To a mixture of propylene glycol, 55 parts, and carbowax (4000),* is added 3 per cent sulfathiazole and 3 per cent sulfadiazine. The mixture is sterilized dry at 140 degrees for one to two hours. If gauze is to be impregnated with the mixture, it is heated to 56 degrees and kept at that temperature overnight. (Instead of sulfonamides, zinc peroxide, 20 per cent, or penicillin, 500 units per gram, may be used.) The carbowax vehicle is water soluble and melts at body temperature. After a generous quantity has been applied to a wound, it is well to cover it with petrolatum gauze to retard evaporation.†

The studies of Howes[140] indicate that 5 per cent sulfamylon (homosulfanilamide, marfanil, mesudin) is superior for local chemotherapy to other substances tested (streptomycin, calcium penicillin, parachlorophenol, tyrothrycin and zephiran). He says: "It possesses the widest range of antibacterial activity and is relatively nontoxic It is active in the presence of pus and blood and is not affected by changes in the acidity of the environment. It possesses rapid bactericidal activity. Sulfamylon in a concentration of less than 3 per cent should not be used. Neutralized sulfamylon should be used." Ackman and Smith[141] say: "The regularly successful elimination of many extensive and even invasive local streptococcal infections by topical sulfonamides alone has conclusively proved the value of the topical chemotherapy for these organisms. . . . Most other wound pathogens, notably Staphylococcus pyogenes, B. proteus vulgaris, Ps. pyocyanea, Cl. welchii, persist in the presence of chemotherapy without necessarily producing clinical infection." Henderson[142]

* Carbide and Carbon Company, New York.

† For a zinc peroxide ointment using carbowax "1540," see Reid and Altemeier.[139]

says, on the other hand, that "for topical application, there seems little justification for the continued use of the sulfonamides."

Colebrook and Francis[143] investigated the effect of applications of sulfanilamide (and sulfathiazole) on 62 superficial wounds. Before treatment was begun, all sloughs were removed, also coagulated exudate, dried pus and remains of tan. "This was effected by saline baths. In some cases eusol dressings were found to be of assistance. Wounds were usually dressed once daily. After removal of the old dressings, which were sprayed with sterile saline to facilitate removal and minimize trauma in cases not receiving saline baths, and after completion of the wound toilet, finely powdered sulfanilamide was insufflated on the wound, and over grafts if these were present, until the appearance resembled a hoar-frost. No advantage was found from heavier powdering. Tulle gras was then applied, and gauze, well moistened with saline, covered this. In order to retain moisture the gauze was covered in turn, by a considerably larger sheet of jaconet or oiled silk, and a firm bandage applied. We would emphasize the importance of this retention of moisture and of applying the powder to the wound surface before a thin film of dried exudate has formed on it—often a matter of only 2 or 3 minutes' exposure. In several instances when attention was not paid to these details, streptococci persisted longer than usual on the wound.

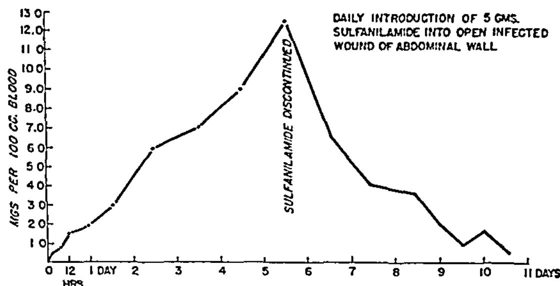


Fig. 20.—Chart showing accumulative rise of sulfanilamide blood concentration when 5 Gm. of the drug is applied daily in an open infected wound. (Veal, J. R., and Klepser, R. G.: Surgery 10: C. V. Mosby Co.)

"When the next dressing was performed 24 hours later the sulfanilamide was found to be completely dissolved on all raw areas, though it was still clearly visible on the surface of grafts, and on the surrounding skin. Solution was not always complete in a few cases in which the wounds were examined after 4 or 6 hours."

Thirty-five patients in their study with sixty-two wounds were observed for several weeks. All of them were infected with hemolytic streptococci. Of the patients, thirty-two received sulfanilamide locally only and three also by mouth. The local application of sulfanilamide to twenty-one patients with thirty-three wounds infected with Streptococcus pyogenes resulted in [illegible]

[illegible] Hemo-

Veal and Klepser[144] obtained excellent results in 300 cases of infected wounds treated after drainage and débridement by the local application of sulfanilamide powder for five to eight days followed by the application of

sulfanilamide, 10 per cent, with allantoin, 2 per cent, in an absorbable glycerinated base. The blood sulfanilamide level showed accumulative rises when 5 Gm. of the drug was applied daily to an open infected wound. (See Fig. 20.)

Diveley and Harrington[145] report that "in a series of 56 cases of infected bone and soft tissue the treatment employed was the administration of sulfathiazole by mouth or sodium sulfathiazole intravenously, thorough débridement of the focus and the introduction of sulfathiazole powder into the wound. In 53 cases healing was by primary intention with an average healing period of twenty-one and six-tenths days."

In many cases of infected wounds it is desirable to employ *oral or intravenous administration of the sulfonamides* in addition to local application to the wounds. The principal drugs used are sulfanilamide, sulfathiazole and sulfadiazine. For infections due to the beta hemolytic streptococcus (Lancefield group A; also B, C, G), sulfadiazine is the first choice and sulfanilamide the second choice. For infections due to alpha hemolytic streptococci (Streptococcus viridans), sulfanilamide is the first choice and sulfathiazole is second. In staphylococcic infections, sulfathiazole is first choice and sulfadiazine is second.[146] In an experimental study, Riba and Aten[147] found that the "healing time and extension of infection were uniformly reduced by introducing powdered sulfathiazole locally into contaminated or infected staphylococcic wounds."

The Surgeon General of the U. S. Army[148] has recommended the sulfonamides in the treatment of various infections as shown in the accompanying table.

With all the great benefits conferred by the sulfonamides, they must be used with caution. Numerous serious sequelae and even fatal results have been reported. Deaths due to sulfathiazole have been reported by Merkel and Crawford,[149] Kennedy and Finland,[150] Hoyne and Larimore,[151] Lederer and Rosenblatt,[152] and Thompson,[153] and also to sulfanilamide by Koletsky.[154]

Fatal granulocytopenia from sulfanilamide has been reported by Schwartz, Garvin and Koletsky,[155] who cite three other cases reported in the literature. Shecket and Price[156] add reports of five more cases and one of their own Britton and Howkins[157] observed transient polymorphonuclear leukopenia in 46 per cent of fifty patients receiving 21 Gm. of sulfanilamide in fourteen days. Thrombopenic purpura following sulfathiazole treatment has been reported by Kracke and Townsend[158] and by Hurd and Jacox.[159] Polyneuritis following sulfanilamide treatment has been reported by Rost.[160] Cline[161] has reported acute yellow atrophy of the liver following the use of sulfanilamide.

The usual manifestations of drug toxicity in adults is conveniently noted in the table on page 54.[162]

From the administration of the sulfonamides there have also been reported toxic hepatitis (fatal case),[163] acute exfoliative dermatitis,[164] nervous injury,[165] and mental confusion and impaired judgment.[166]

Winsor and Burch[167] made a study of the renal complications in sulfathiazole therapy. They concluded:

"To reduce the incidence of renal damage, certain rules should be followed: (a) Check previous sulfonamide medication in order to prevent overdosage. (b) Evaluate the state

Choice of Sulfonamides in Various Infections as Recommended by the Surgeon General, U. S. Army[119]

Type of Infection	*Drug of Choice*	*Oral Administration* *Initial Dose*	*Oral Administration* *Subsequent Doses*	*Parenteral Administration*
Mild hemolytic streptococcus	Sulfadiazine	4.0 Gm.	1.0 Gm. q. 4 hr., 5 days	Intravenous sodium sulfadiazine, 0.10 Gm. per kilo body wt. plus oral, or ½ dose intravenous
Severe hemolytic streptococcus	Sulfadiazine	4.0 Gm.	1.0 Gm. q. 4 hr. until temp normal 7 days	
Gas bacillus	Sulfathiazole	6.0 Gm.	1.0 Gm. q. 4 hr. until temp normal 48 hr.	
Staphylococcus	Sulfathiazole or sulfadiazine	4.0 Gm.	1.5 Gm. q. 4 hr. until spreading of infection ceases; then 1.0 Gm. q. 4 hr. for 7 days.	

MANIFESTATIONS OF DRUG TOXICITY NOTED IN ADULTS TREATED WITH SULFANILAMIDE, SULFAPYRIDINE, SULFATHIAZOLE, SULFAGUANIDINE [SULFANILYLGUANIDINE]†, OR SULFADIAZINE (Office of Surgeon General, Circular Letter No. 17, Feb. 23, 1942)

Reaction	Sulfanilamide	Sulfapyridine	Sulfathiazole	Sulfadiazine
Nausea, vomiting	Fairly common	Frequent	Uncommon	Uncommon
Dizziness	*Common*	*Common*	Uncommon	Uncommon
Psychoses*	0.6%; occur early	0.3%; occur early	Rare	Questionable
Neuritis**	Very rare	Not reported	Rare	Not reported
Cyanosis	Very common, early and late	Faint, common, early and late	Uncommon	Rare
Acidosis*	1.9%; occurs at any time	None	None	None
Fever*	10%; generally 5th to 9th day; may occur 1st to 30th day	4%; generally 5th to 9th day; may occur 1st to 30th day	10%; generally 5th to 9th day	Uncommon; 1%
*Rash**	1.9%; *may take any form,* generally 5th to 9th day; may occur 1st to 30th day	2%; *may take any form,* 5th to 9th day; may occur 1st to 30th day	5%; nodular type, common; may take any form, 5th to 9th day	Uncommon; 2%
Hepatitis*	0 6%; early or late	Not seen, but reported	Rare	Not reported
Leukopenia with granulocytopenia**	0.3%; early or late	0.6%; early or late	1.6%; early or late	Rare
Acute agranulocytosis**	0 1%; occurs 14th to 40th day; *common 17th to 25th day*	0.3%; occurs 14th to 40th day; *common 17th to 25th day*	Reported	Reported
Mild, hemolytic anemia	3%; early or late	Rare	Rare	Rare
Acute hemolytic anemia**	1.8%; occurs 1st to 5th day	0.6%; occurs 1st to 5th day	Very rare	Very rare
Hematuria*	Not reported	8%; generally early	2.5%; generally early	1%
Anuria with azotemia**	Not reported	0.3%; generally first 10 days	0.7%; generally 1st 10 days	Rare
Hyperleukocytosis*	Generally in presence of acute hemolytic anemia	Generally in presence of acute hemolytic anemia	Not reported	Not reported
*Injection of sclerae and conjunctivae***	Not reported	Not reported	4%; *may occur with rash and* fever, 5th to 9th day	Rare; *0.3%*
Purpura hemorrhagica**	Not seen, but reported	Not seen, but reported	Not reported	Not reported
Ocular and auditory disturbances**	Rare	Rare	Very rare	Not reported
Jaundice**	With acute hemolytic anemia or hepatitis	With acute hemolytic anemia or hepatitis	With acute hemolytic anemia or hepatitis	Not reported
*Painful joints**	*Reported*	*Not reported*	*Reported with rash, etc.*	Not reported
Stomatitis*	Rare	Not reported	Not reported	Not reported
Gastro-intestinal tract disturbances*	Bleeding, rare, diarrhoea uncommon	Rare	Very rare	Not reported

* Best to stop drug and force fluids. ** Imperative to stop drug and force fluids.
† Sulfaguanidine has shown little toxicity to date. Drug rash and fever have been noted.

Martin and his associates,[169] working with mice, found that the toxicity of sulfanilamide was reduced 20 to 40 per cent by the simultaneous administration of a single dose of calcium gluconate and that the efficacy of the sulfanilamide was not impaired. Other detoxifying compounds also were used.

Erskine[170] recommends that whenever possible small doses of the sulfonamides be used in some chronic infections so as to desensitize the patient, especially as the drugs are used for so many common illnesses and because often a patient in whom a sensitivity of this type develops may remain allergic for a long time. Sometimes the first tablet given months later may provoke an immediate return of a dermatitis with general symptoms, and these reactions may occasionally be of an alarming nature. Delayed reactions have not been observed when desensitization was undertaken at the time of the reaction. If chemotherapy is restricted, whenever possible, to seven days or less the incidence of allergic sensitivity is considerably reduced. Sensitivity almost invariably appears between the eighth and tenth days of treatment and depends more on the factor of time than on the total dose employed. Occasionally delayed reactions appear up to forty-eight hours after chemotherapy has been stopped, so that administration for more than six days makes sensitivity a possibility. Absorption from local application as well as oral or parenteral administration may lead to sensitization phenomena. Desensitization should be undertaken immediately if eighth day "allergic" sensitization is encountered. The drug should be withheld if Werner's test indicates drug retention. In photosensitization the drug may be safely continued if further exposure to sunlight is avoided.

The sulfonamides in combination with other agents have been found helpful in the treatment of infected wounds. Meleney and Harvey[171] have found that the oral administration of sulfanilamide combined with the local application of 40 per cent zinc peroxide in sterile distilled water gives excellent results in the treatment of chronic undermining burrowing ulcers due to the microaerophilic hemolytic streptococcus. In various infected wounds, Veal and Klepser[172] have had excellent results with an ointment composed of sulfanilamide, 10 per cent; allantoin, 2 per cent; chlorobutanol, 0.5 per cent, mixed with a greaseless base composed of glycerinated stearic acid ointment with triethanolamine to desired consistency.[173] Goldberger[174] believes that the combination of sulfanilamide and sulfathiazole is more effective for local use than either alone. Holder and MacKay[175] have used a mixture of sulfanilamide (10 per cent) and carbamide (urea) in infected wounds with success. Neter[176] used a solution composed of azochloramide (0.2 per cent), sulfanilamide (2.25 per cent), sodium tetradecyl sulfate (0.1 per cent), and triacetin (97.45 per cent).

Antibiotics in Infected Wounds: (a) Penicillin.—Penicillin is a filtrable substance obtained from a mold[177] which has powerful antibacterial activity against the pyogenic cocci, hemolytic streptococci, pneumococci and others. It is prepared by culture of the mold extract with an organic solvent. Experimentally, penicillin has been shown capable of protecting animals from overwhelming infections of beta hemolytic streptococci or pneumococci.[178] It has an almost complete absence of toxicity, and its bacteriostatic power against streptococci and staphylococci is much greater than that of the sulfonamides. It does not show leukocyte activity in vitro. Experiments suggest that its local application is innocuous to tissue cells.[179] Herrell and his associates[180] obtained a brilliant result with penicillin in a desperate case of facial and orbital cellulitis due to Staphylococcus aureus and complicated by septicemia. The sulfonamides had been ineffectual in this case. Herrell[181] has had good results in 7 other cases of Staphylococcus aureus infection. Penicillin may be employed locally (topically) or systemically in infected wounds.

With the *local* use of penicillin an enormous concentration can be achieved in the wound. Grace and Bryson[182] found "definite advantages in the use of 4000 units per cubic centimeter in isotonic solution of sodium chloride with 0.1 per cent of the detergent sodium tetradecyl sulfate for local application to chronically infected areas of bone and soft tissue, and for the treatment of infected amputations." Cutler and Sandusky[183] use dehydrated human plasma as a vehicle for the local administration of penicillin. They say: "Under sterile conditions the sodium salt of penicillin is mixed with commercially prepared dehydrated plasma. From 10,000 to 20,000 units of penicillin to 0.2 Gm. of plasma is a desirable proportion; however, this ratio can be varied to fit the particular need. The plasma tends to be lumpy, but gentle stirring reduces it to a light fluffy powder. Penicillin is added,and after gentle stirring, a homogenous mixture is obtained. As plasma is used almost daily in our hospitals, we suggest, to avoid wastage, that the portion of plasma not mixed with the penicillin be used immediately for intravenous therapy. Uniform distribution of this mixture on the wound surface is accomplished by means of a powder insufflator. . . . When sprayed on a wound surface, the penicillin-plasma mixture immediately goes into solution and the tissues assume a yellow color. Complete hemostasis must be attained before insufflation; otherwise the mixture will be washed off at once. We have observed that 0.2 Gm. of plasma is sufficient for fine frosting of a surface 100 sq. cm. in area."

Howes[184] finds penicillin inferior to streptomycin and sulfamylon. He says: "It is non-toxic, but penicillin is readily destroyed by changes in *p*H and possesses a very narrow range of bacterial activity. Resistant strains are not infrequently encountered and this antibiotic becomes almost worthless in the presence of a mixed infection. Penicillin does not destroy mixed bacteria, and, conversely, penicillin is destroyed."

Meleney et al.[185] call attention to the fact that gram-negative organisms and most of the aerobic gram-positive spore-forming bacilli (B. subtilis group) when present in wounds may destroy penicillin. Meleney has found parachlorophenol* to be the most effective agent against gram-negative organisms. He says: "For clinical use a 1:400 concentration in isotonic solution of sodium chloride or in a carbowax 4000-propylene glycol (45 to 55 per cent by weight) ointment base was used for local application to infected wounds. Its systemic toxicity when injected subcutaneously into mice is 0.6 mg. per gram of body weight. A corresponding dose for man would be 40 Gm. or about 16 Kg. of ointment as prepared for clinical use, which is well above any amount likely to be used. In solution and in the carbowax ointment it has a not unpleasant phenolic odor." The penicillin is combined with the parachlorophenol in the treatment of infected wounds as follows: "The ointment is prepared by melting 45 parts of carbowax 4000 with 55 parts of propylene glycol together either over a free flame or in a hot water bath. When they are thoroughly mixed they are sterilized in a dry oven at 140 C. for four hours and then allowed to cool. As they begin to solidify at 40 C. the penicillin (1000 units per gram) and parachlorophenol (0.25 per cent) are added. At this stage the ointment may be incorporated sterilely into fine meshed gauze (piece by piece cut to a convenient size) and placed in a pile of fifty or more in a container. A pint or quart sized ice cream box serves as an excellent container. Both the ointment and the impregnated gauze should be kept in the

* Obtained from the Eastman Kodak Co., Rochester, N. Y.

ice box until ready for use." (Meleney et al.) Smith-Petersen et al.[186] use a special vitallium cannula to irrigate infected osteomyelitis wounds with a solution containing 250 units of penicillin per cubic centimeter. Myers et al.[187] obtained favorable results in the treatment of surface infections with the use of gauze inoculated with Penicillium notatum or impregnated with crude penicillin. Penicillin may be used for local application in carbowax (4000) in mixture of 500 units per gram.[188]

Penicillin may also be employed *systemically* in infected wounds. At this point it may be wise to give a general statement as to the general indications, dosage and administration of penicillin. For this purpose it will be well to quote from the excellent article by Keefer et al.:[189]

"The suggestions regarding indications, dosages and precautions reflect as closely as possible the experience of experts in penicillin therapy. These suggestions are necessarily conservative, since experience with many of these products has been limited and there are many questions yet unanswered. As additional evidence accumulates it may be possible to extend the indications and alter the dosage schedules set forth in the following paragraphs:

"Parenteral Products: Sodium penicillin and calcium penicillin are so purified and dried that the final products have a potency of not less than 500 units per milligram. They are sterile, nontoxic and nonpyrogenic and have a moisture content of not more than 2.5 per cent. They are packaged in 100,000 unit, 200,000 unit, 500,000 unit, 1,000,000 unit and 5,000,000 unit sizes. . . .

"*Group I Indications:*

"1. All staphylococcic infections with and without bacteremia: Acute and chronic osteomyelitis. Carbuncles—soft tissue abscesses. Meningitis. Cavernous or lateral sinus thrombosis. Pneumonia—empyema. Carbuncle of kidney. Wound infections—burns. Endocarditis.

"2. All cases of clostridia infections: Gas gangrene. Malignant edema.

"3. All hemolytic streptococcic infections with bacteremia and all serious local infections: Cellulitis. Mastoiditis with intracranial complications, i. e.: meningitis, sinus thrombosis and so on. Pneumonia and empyema. Puerperal sepsis. Peritonitis. Endocarditis.

"4. All anaerobic streptococcic infections: Puerperal sepsis. Localized infections elsewhere.

"5. All pneumococcic infections of: Meninges. Pleura. Endocardium. All cases of sulfonamide-resistant pneumococcic pneumonia.

"6. All gonococcic infections.

"7. All cases of anthrax.

"8. All cases of chronic pulmonary suppuration in which surgical treatment is contemplated.

"9. All meningococcic infections failing to respond to sulfonamides.

"10. All cases of bacterial endocarditis due to susceptible organisms.

"11. Erysipeloid (swine erysipelas).

"12. Vincent's infection.

"13. Prophylactic use in prevention of possible secondary infection following tonsillectomy and tooth extraction in cases with a history of rheumatic fever or in rheumatic heart disease, in congenital heart disease and in other conditions in which secondary infection may occur (infected teeth, tonsils).

"*Group II Indications:* Penicillin has also been found to be an effective agent in the following diseases, but its position has not been definitely defined and

will require additional experimental work: 1. Syphilis. 2. Actinomycosis. 3. Diphtheria, in conjunction with antitoxin.

"*Group III Conditions of Questionable Value:* Penicillin is of questionable value in mixed infections in which the predominating organism is of the gram negative flora—i. e.: 1. Ruptured appendix with peritonitis. 2. Liver abscesses. 3. Urinary tract infections due to Escherichia coli. 4. It is also of questionable value in rat bite fever due to Streptobacillus moniliformis.

"*Group IV Conditions in Which Penicillin is Ineffective:* 1. All gram negative bacillary infections: Typhoid—paratyphoid. Dysentery. Escherichia coli. Hemophilus influenzae. Bacillus proteus. Bacillus pyocyaneus. Brucella melitensis (undulant fever). Pasteurella tularensis (tularemia). Friedländer's bacillus. 2. Tuberculosis. 3. Toxoplasmosis. 4. Histoplasmosis. 5. Acute rheumatic fever. 6. Lupus erythematosis, diffuse. 7. Infectious mononucleosis. 8. Pemphigus. 9. Hodgkin's disease. 10. Acute and chronic leukemia. 11. Ulcerative colitis. 12. Coccidioidomycosis. 13. Malaria. 14. Poliomyelitis. 15. Blastomycosis. 16. Nonspecific iritis and uveitis. 17. Moniliasis. 18. Virus infections. 19. Cancer.

"*Method of Preparing Penicillin for Treatment.*—As penicillin is extremely soluble, it may be dissolved in small amounts of sterile distilled, pyrogen-free water in sterile isotonic solution of sodium chloride or in sterile 5 per cent dextrose solution. When large unit sizes are being used in hospitals, the contents of the ampule should be dissolved in water or saline solution so that the final concentration is 5000 to 50,000 units per cubic centimeter, depending on the circumstances of the case. This solution should be stored under aseptic precautions in the ice box and made up freshly every day. Solutions for local or parenteral use may be diluted further, depending on the concentration desired.

"A. For intravenous injection:

"1. The dry powder may be dissolved in sterile isotonic solution of sodium chloride in concentrations of 10,000 to 50,000 units per cubic centimeter for direct injection through a syringe.

"2. The dry powder may be dissolved in sterile saline solution or 5 per cent glucose solution in lower dilution (25 to 50 units per cubic centimeter) for constant intravenous therapy.

"B. For intramuscular injection:

"1. The total volume of individual injections should be small, i. e., 10,000 to 50,000 units per cubic centimeter of isotonic solution of sodium chloride. It may also be given by constant intramuscular drip, 120,000 units in 250 cc.

"*Methods of Administration of Penicillin.*—There are three common methods of administering penicillin—intravenous, intramuscular and topical. Subcutaneous injections are likely to be painful and should be avoided. The route of choice is intramuscular.

"*Dosage.*—The dosage of penicillin will vary from one patient to another depending on the type and severity of infection. The objective in every case is to bring the infection under control as quickly as possible. In most cases a minimum of 100,000 units daily will be required.

"It is well to remember that penicillin is excreted rapidly in the urine so that following a single injection it is often impossible to detect it in the blood for a period longer than two to four hours. It is well, therefore, to use

repeated intramuscular or intravenous injections every three or four hours or to administer it as a continuous infusion.

"A. In serious infections with or without bacteremia an initial dose of 15,000 or 20,000 Oxford units with continuing dosage as:

"1. Constant intravenous injection of isotonic solution of sodium chloride containing penicillin so that 5000 to 10,000 Oxford units is delivered every hour, making a total of 120,000 to 240,000 units in a twenty-four hour period. One half of the total daily dose may be dissolved in a liter of isotonic solution of sodium chloride and allowed to drip at the rate of 30 to 40 drops per minute.

"2. If a continuous intravenous drip is undesirable, 20,000 to 40,000 units may be injected intramuscularly every three or four hours.

"3. After the temperature has returned to normal, the penicillin may be continued as long as there are any signs of active infection.

"B. In chronically infected compound injuries, osteomyelitis and the like the dosage schedule should be 20,000 units every two hours or 40,000 units every four hours parenterally with local treatment as indicated. This dosage schedule may have to be increased, depending on the seriousness of the infection and the response of treatment. The best results are obtained in these cases when penicillin is combined with adequate surgical treatment.

"C. Gonorrhea: 1. Twenty-five thousand units every three hours intramuscularly for five doses. The results of treatment should be controlled by culture of exudate. All patients failing to respond to the first course should be retreated.

"D. Empyema: 1. Penicillin in isotonic solution of sodium chloride should be injected directly into the empyema cavity after aspiration of pus or fluid. This should be done once or twice daily, using 50,000 or 100,000 units, depending on the size of the cavity, type of infection and number of organisms. Penicillin solution should not be used for irrigation.

"E. Meningitis: 1. Penicillin does not penetrate the subarachnoid space in appreciable amounts, so that it is necessary to inject penicillin into the subarachnoid space or intracisternally in order to produce the desired effect. Ten thousand units diluted in isotonic solution of sodium chloride in a concentration of 1000 units per cubic centimeter should be injected once or twice daily, depending on the clinical course and the presence of organisms.

"F. Bacterial Endocarditis: 1. Penicillin is the best agent available for the treatment of bacterial endocarditis. Penicillin alone is as effective as penicillin combined with heparin. The treatment should be continued for three weeks or longer, depending on the individual case. The intramuscular route is the one of choice, although in a few instances it may be desirable to use the continuous intravenous route in order to obtain the maximum effect. The dosage should range from 200,000 to 300,000 units a day if the best results are to be obtained.

"*Penicillin with Diluent:* Penicillin with diluent is a combination package of penicillin and a suitable solvent such as water for injection, 5 per cent dextrose injection or isotonic solution of sodium chloride.

"*Indications and Dosage.*—Same as for sodium penicillin and calcium penicillin.

"*Penicillin in Oil and Wax:* Penicillin in oil and wax is a suspension of calcium penicillin in a menstruum of refined peanut oil in which white wax

is dispersed. It is packaged in 100,000 units per cubic centimeter, 200,000 units per cubic centimeter and 300,000 units per cubic centimeter concentration. The white wax content of the 100,000 units per cubic centimeter and 200,000 units per cubic centimeter concentrations is not less than 3 per cent and of the 300,000 units per cubic centimeter concentration not less than 4.7 nor more than 4.9 per cent. The calcium penicillin used in the 300,000 unit per cubic centimeter concentration has a potency of not less than 900 units per milligram, and that in the other concentrations has a potency of not less than 750 units per milligram.

"*Indications and Dosage.*—Gonorrhea, acute staphylococcic and streptococcic infections and pneumonia.

"All conditions require a minimum of 300,000 units per day. Preparations containing 200,000 units per cubic centimeter may be administered at twelve hour intervals. If the quantity is 100,000 units per cubic centimeter, administration at eight hour intervals is necessary. Rotation of the site of injection is desirable; the upper outer quadrants of the buttocks, the anterior thighs and triceps are suggested sites.

"*Gonorrhea.*—Three hundred thousand units as a single injection or 200,000 units as an initial injection followed by 100,000 units in twelve hours, or three injections at eight hour intervals of 100,000 units each. In the presence of complications such as arthritis, endocarditis and epididymitis the dosage should be intensified and prolonged.

"*Pneumonia and Acute Staphylococcic and Streptococcic Infections.*—A minimum of 300,000 units daily, preferably in divided doses and continued until the temperature returns to normal and other evidence of infection disappears.

"*Precautions.*—DO NOT USE INTRAVENOUSLY. Do not use in those conditions listed in groups III and IV under 'Sodium Penicillin' and 'Calcium Penicillin.'[190]

There is increasing interest in the *oral* administration of penicillin. Ross et al.[191] say:

"1. Adequate therapeutic blood concentrations of penicillin after oral administration can be obtained when the drug is protected against inactivation by gastric acidity. A method of providing this protection by the use of a double gelatin capsule hardened by formaldehyde-alcohol immersion together with preliminary neutralization of the hydrochloric acid in the stomach was adopted.

"2. Administration of a 100,000 unit capsule every three hours by this method provides constant therapeutic penicillin levels well within or above the effective antibacterial range of most susceptible organisms throughout the course of treatment.

"3. A clinical trial of this method on 10 children with gonorrhea, 2 with pneumonia and 2 with cellulitis resulted in prompt recovery.

"4. The relatively large doses of penicillin employed produced no toxic manifestations."

Finland et al.[192] say: "A dose of 90,000 units of penicillin given by mouth one-half hour before breakfast regularly gave serum levels comparable with those obtained from 15,000 or 20,000 units given intramuscularly. The levels obtained in the serum when the same amount of penicillin was given one-half hour after breakfast were very irregular and unpredictable. . . . Effective

penicillin levels could be fairly well maintained with several oral preparations given in 90,000 or 100,000 unit doses every two hours." Cutting et al.[193] have had favorable experience in the treatment of gonorrhea by the oral administration of penicillin.

Penicillin in doses of 50,000 units at a time has been administered by continuous intramuscular infusion[194] and by intra-arterial injection[195] in severe infections of the extremities with successful results.* One to four injections are given. Loewe et al.[196] have found that "prolonged, effective penicillin levels have been obtained following the administration of penicillin by rectal suppository."[197]

(*b*) *Tyrothricin.*—Tyrothricin† is an antibiotic composed of a mixture of gramicidin, which is active against gram-positive organisms, and tyrocidine, which is active against both gram-positive and gram-negative organisms. Tyrothricin is used topically in the form of wet dressings, irrigations and instillations. A concentration of 33 mg. per hundred cubic centimeters is suitable unless there is irritation when a weaker solution is used as a preliminary test. Each cubic centimeter of the 2 per cent alcoholic commercial solution is diluted with 60 cc. of sterile water to form a colloidal suspension. The solutions should be freshly prepared and used within twenty-four hours. Tyrothricin has been beneficial in the treatment of various types of ulcers of the extremities, osteomyelitis and empyema. Meyer and Kozoll[198] recommend tyrothricin for local application for varicose ulcers in wet dressings of 1 mg. of tyrothricin per cubic centimeter. Henderson[199] says: "Tyrothricin is an excellent agent for this purpose, particularly for the irrigation of empyema cavities and the urinary bladder, since its activity is not decreased in the presence of purulent discharges. The local use of tyrothricin frequently may be combined advantageously with the systemic use of penicillin or the sulfonamides. Tyrothricin also is satisfactory for the treatment of vascular ulcers of the extremities, the preparation of infected areas for skin grafting, and the topical prophylaxis of gram-positive wound infections."

(*c*) *Streptomycin.*—Streptomycin is an antibiotic derived from Actinomyces griseus.[200] Herrell and Nichols[201] say: "It is evident from the reports from the Clinic[202] and also from the reports of Elias and Durso[203] and Zintel and his colleagues[204] that following the systemic administration streptomycin is readily absorbed and reaches the general circulation. It is further evident from these reports that streptomycin, not unlike penicillin, is excreted readily by the kidneys and on occasions half to two thirds of the total amount administered is excreted in the urine within the first twenty-four hours. Following administration of streptomycin by single subcutaneous, intravenous or intramuscular injection, the level in the blood serum reaches a peak in one to two hours and gradually falls off. If repeated injections of 100,000 units of streptomycin are made, it is possible at times to build up concentrations in the blood serum to levels as high as 12 units and in some instances to 25 units of streptomycin per cubic centimeter. It further appears that streptomycin is excreted through the bile. It seems evident, also, that the substance is concentrated in the bile. In human subjects without disease of the cerebrospinal apparatus, streptomycin does not readily diffuse into the cerebrospinal fluid; however, in the presence of meningitis, amounts sufficient to check the growth of bacteria may reach the cerebrospinal fluid after repeated injections. Likewise, it appears that streptomycin passes rather readily through the placenta and reaches the fetal circulation after its administration to a pregnant woman. After the systemic administration of streptomycin, little or none can be found in the feces. Conversely, when the substance is administered orally, little of it diffuses into the blood stream and, therefore, little or none appears in the urine. For this reason oral administration

* For technic, see section on Minor Surgical Technic.

† Tyrothricin is supplied by Parke, Davis & Co.

is not suitable for use in the treatment of infections in general. Streptomycin is not destroyed in the fecal stream and, therefore, it may be used orally in an attempt to rid the intestine of certain organisms susceptible to its action. This property of streptomycin immediately suggests its possible value when given orally in the preparation of patients for operative procedures involving the intestine."

Streptomycin is administered intramuscularly (125,000 units in 1 or 2 cc of water or saline solution every three to four hours or by continuous drip), subcutaneously (100,000 units per cubic centimeter), intrathecally (100,000 units in 5 or 10 cc. of saline solution), by nebulization, and orally (500,000 to several million units in four divided doses).

Herrell and Nichols summarize their study as follows: "The antibiotic agent, streptomycin, appears to possess therapeutic possibilities which deserve further clinical investigation. No serious irreversible toxic effects have been encountered from its use for forty-five patients suffering from a variety of infections owing to organisms sensitive to its action. Included in this report are eight cases of bacteriemia, in six of which recovery occurred. Doubtful results were obtained in two cases of undulant fever associated with bacteriemia. Good results were obtained in ten of thirteen cases of moderately severe and severe infections of the urinary tract owing to a variety of pathogenic organisms. Of five cases of infection involving the tracheobronchial tree, satisfactory results were obtained in four. Included in the report are four cases of syphilis in which it is doubtful whether treatment with streptomycin was effective although the amount of streptomycin administered was [illegible]

[illegible] clinical studies must be completed before final statements can be made concerning the *efficacy of streptomycin in other of these infections.*"

Hirshfeld et al.[205] find that "streptomycin does not sterilize walled-off collections of pus, even though the organisms involved are susceptible to its action." Howes[206] finds streptomycin superior to penicillin and says: "It failed to attack the streptococcus in concentrations of 200 units per cubic centimeter, and this antibiotic is destroyed by increasing the acidity of the environment."[207]

[illegible] 88 per cent.

Pectin.—Pectin (in 2 to 10 per cent solutions containing 1:200,000 aqueous merthiolate) has given excellent results as a moist dressing for infected wounds.[208] Pectin and nickel pectinate have shown value in healing of wounds in experimental animals.[209]

Cod Liver Oil.—Cod liver oil dressings for infected wounds have received very favorable endorsement. The dressings may be soaked in cod liver oil or covered with a thick layer of an ointment of 25 per cent cod liver oil in vaselin.[210] Hardin,[211] in an excellent clinical paper, says that he regards cod liver oil ointment as "superlative" for the treatment of both clean and infected wounds.

B.I.P.P. (Bipp) and Liquid Paraffin.—Bipp and liquid paraffin treatment of wounds has had great success in the hands of the British and Canadians, since its introduction by Morison[212] in 1918. Bipp consists of one part bismuth subnitrate, two parts iodoform powder, and about one part liquid paraffin, sufficient to make a thick paste. The bipp is applied to all parts of the wound, and the excess is removed. The wound is then packed with soft gauze soaked in liquid paraffin to which a small amount of bipp has been added. Firm pressure dressings or plaster casts are then used.[213]

Azochloramide.—Azochloramide (in triacetin 1:500, or in "surface active" saline mixture) is a useful agent in the treatment of infected wounds. It combines low tissue toxicity with high bactericidal potency.[214] Its use in infected

wounds has been praised by Johnson,[215] Van Wagoner,[216] Young,[217] Kennedy,[218] Freeman[219] and Newell.[220] Neter[221] has shown that azochloramide enhances the action of sulfanilamide under certain conditions.

In the *deodorization of the fungating wounds of malignant disease*, Geschickter and Copeland[222] recommend azochloramide. They advise that a large pad of gauze—six to eight layers in thickness—be saturated in azochloramide in 1:500 triacetin solution and then applied directly to the wound and covered with rubberized silk. A layer of bandaging is then applied. A fresh dressing is applied daily or every other day. For deodorizing wounds and fistulas, Babcock[223] uses a 1:300 or 1:500 aqueous solution of potassium permanganate or a 1:500 to 1:2000 bromine solution. Zinc peroxide, especially the convenient commercial preparation "Perguent," is useful in diminishing the odor from a wound if the odor is due to anaerobic organisms. For ill-smelling casts Silver and Rusbridge[224] apply daily to the odorous portion a mixture of

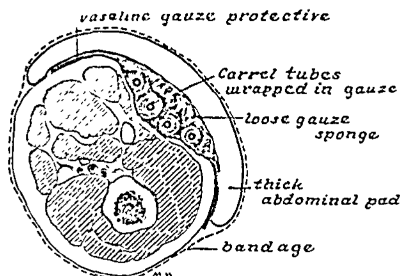


Fig. 21.—Carrel-Dakin treatment. Cross section of an extremity showing the details of the dressing. The Carrel tubes are wrapped in gauze and held in the wound by loose gauze packing.

iodoform 3.0 and tr. benzoin comp. q.s. ad 240.0. Regan and Henderson[225] cover the ill-smelling cast with a charcoal wool-filter cloth sack.

Urea.—The use of urea crystals in infected wounds has received the endorsement of Muldavin and Holtzmann.[226] In their cases of this type the wound was syringed free from pus and necrotic material with a saturated solution of urea, excessive moisture was removed and urea crystals were then liberally applied. Waxed paper was placed over the crystals to keep them in contact with the wound and to prevent the dressings from becoming soaked. This had the further advantage that it prevented the dressings from sticking to the raw surface of the wound. In all but small wounds, zinc cream was spread over the adjacent skin. This was used as a precaution, since some moisture will reach the surrounding skin however carefully a discharging wound is dressed. Owing to the extreme diffusibility of urea when combined with a saturated solution for syringing, even the deepest wound can be treated effectively. After two or three applications, sloughs disappear and also any foul odor.

Dakin's Solution (Carrel-Dakin Technic).—In large infected wounds, the

Carrel-Dakin treatment is often useful. The skin in the neighborhood of the wound is first cleansed with a neutral soap solution and dried with sterile gauze. Sheets of petrolatum gauze are then applied about the wound edges. This petrolatum gauze is often made with a small amount of resin to make it more adherent. It should be applied in layers of one thickness only and should be devoid of wrinkles. All parts of the skin up to the edges of the wound should be carefully covered. The purpose of the petrolatum gauze is to protect the skin from the irritating action of the Dakin solution. The Dakin solution, which is 0.45 to 0.5 per cent solution of hypochlorite of soda and requires considerable skill in its preparation, is administered to the depths of the wound by the Carrel tubes. These are small rubber tubes which are tied off at the distal end and contain a varying number of small perforations, according to the shape and size of the wound. The tube is loosely wrapped in gauze which has been moistened with Dakin's solution and placed in the wound. Other pieces of gauze, likewise moist, are loosely packed in on top of this so that the tube or tubes are held in position (Fig. 21). The tube or tubes are then so arranged that at regular intervals, generally two hours, a given quantity of Dakin's solution, generally 10 cc., may be instilled with a hand syringe. The dressings are changed every twenty-four hours, the depths of the wound are gently cleansed with neutral soap and freshly sterilized tubes are put in place. An essential of this treatment is the periodic examination of smears made from the wound surface. When the wound has become consistently free from bacteria, operative closure is to be considered.

For further details of the Carrel-Dakin treatment the reader is referred to the book entitled "Infected Wounds," by Carrel and Dehelly.[227]

In broad, shallow wounds, such as varicose ulcers, various ointments are of benefit. Included in these are scarlet red ointment, the Credé or metallic silver ointment and mercurochrome ointment.[228]

Zinc Peroxide.—In 1935 Meleney[229] introduced zinc peroxide in the treatment of infections due to anaerobic or microaerophilic organisms. The virtue of zinc peroxide lies in the fact that it will liberate oxygen over many hours.* Its usefulness was first described by Meleney in cases of spreading ulcerations of the abdominal wall associated with a hemolytic microaerophilic streptococcus. (See section on infectious gangrene.) It is now felt to be somewhat effective against the aerobic hemolytic streptococcus.

Before any use is made of zinc peroxide, careful aerobic and anaerobic cultures of the wound must be made to see if a susceptible organism is present.

Meleney and Johnson[230] have given such important advice regarding the employment of zinc peroxide that it is herewith reproduced verbatim:

"It is particularly indicated in those foul smelling infections of dental origin which occur in the face or neck in which the anaerobic nonhemolytic streptococcus and the spirochetes and fusiform bacilli of Vincent and Plaut are the etiological agents. Likewise in neck infections from perforations of the esophagus which are particularly virulent and necrotizing in their effect. Lung abscesses and chronic empyemas following lung abscess are particularly amenable to treatment with zinc peroxide, and the gratifying deodorant effect is almost immediately noted and appreciated by the patient and the whole ward. Chronic abdominal sinuses, either fecal fistulas or those arising superficially and invading the deeper tissues, are frequently due to susceptible organisms of intestinal origin. Progres-

* Meleney has found that the zinc peroxide manufactured by the du Pont Chemical Company of Niagara Falls, N. Y.; Merck & Co., and Mallinckrodt Chemical Works is satisfactory.

sive gangrenous infections of the skin due to a synergistic bacterial action or chronic undermining burrowing ulcers of the nongangrenous type are indications for the use of zinc peroxide after the necessary preliminary surgery which will permit close application of the medication.[231] Human bites fall into the same category.

"Gas gangrene or tetanus resulting from gunshot wounds or street injuries should be treated with zinc peroxide after the involved areas have been adequately cleaned. Occasionally gas gangrene has occurred following the amputation of gangrenous extremities or after the hypodermic or intramuscular injection of medication. In recent months we have treated all of these forms of infection successfully with zinc peroxide.

"We have also been using zinc peroxide as a prophylactic in accidental and surgical operative wounds where contamination with anaerobic and micro-aerophilic organisms was suspected or inevitable. As one would expect, the prophylactic use of this material is more logical than the active treatment because the organisms have not yet invaded the tissues, but are merely on the surface. The application of zinc peroxide to the wound surfaces gives intimate contact with the organisms so that they are either killed promptly by the action of the zinc peroxide or are prevented from gaining a foothold and multiplying in the tissues and are either destroyed by leucocytes or are washed out of the wound. In such cases, as in the treatment of active infections, the zinc peroxide must be applied to every part of the wound surface because its action does not extend very far from its actual presence. Clinically it acts very much the same as it does on a blood agar plate. If a drop of zinc peroxide suspension is placed upon the surface of blood agar which has been evenly seeded with susceptible bacteria, after incubation a narrow zone about $\frac{1}{16}$ of an inch wide will be seen around the drop; in this zone there will be no growth of bacteria, whereas the rest of the plate will be evenly covered with luxuriant growth.

"Inasmuch as anaerobic and micro-aerophilic organisms are prevalent throughout the alimentary canal and in the vagina, zinc peroxide is indicated prophylactically before all operations on the mouth, such as plastic procedures or the removal of tumors of the mucous membrane. One is surprised by the lack of inflammatory reaction of the mucous membrane when it is used as a mouth wash before and after such procedures. No untoward results have followed the ingestion of zinc peroxide when it is so employed. It should be used before all dental extractions as a means of preventing those foul infections so frequently seen in the tooth socket and in the neck after dental work. In these infections the nonhemolytic anaerobic streptococci and the spirochetes and fusiform bacilli of Vincent and Plaut are active, probably in symbiosis. For the same reason, zinc peroxide is indicated in all human bites. In these cases the wounds should be opened widely and thoroughly cleaned so that contact may be had with the fullest depths of the wound. The destructive action of these infections, if they gain a foothold, with their tendency to invade bones and joints and tendons, is well known. If zinc peroxide were used before and after tonsillectomies, those extensive sloughs and the occasional fatal septicemia or lung abscess which are the bane of the throat specialists would, we believe, be greatly diminished. Operative or accidental wounds of the esophagus should always be left open and packed with gauze soaked in zinc peroxide suspension and the dressing renewed daily. Colostomies or cecostomies should be surrounded by packing soaked in zinc peroxide, both preliminary to and after their opening. Recently one of our surgeons has had a patient who developed an extensive gas gangrene of the abdominal wall when this was not done. Fortunately excision followed by the application of zinc peroxide controlled the infection. After excision of an anal fistula or fissure, the tract should be packed with gauze soaked in zinc peroxide suspension. The lack of inflammatory reaction and pain and tenderness will be noted both by doctor and patient when this is used. After hemorrhoidectomy the anal ring should be similarly packed during the postoperative period of enforced constipation. The patients so treated have almost invariably stated that pain was surprisingly absent after operation. In recent years gauze soaked in zinc peroxide has entirely replaced iodoform gauze in our practice.

"For several years we have been using zinc peroxide as a preparation for the vagina preliminary to hysterectomy or the plastic procedures on the female perineum, and we [illegible]

indicated as a prophylactic, for the anaerobic organisms of tetanus or gas gangrene are always to be feared. If war ever comes again, and pray God that it will not, we believe that zinc peroxide will have a wide field of usefulness in every army hospital."

Method of Application of Zinc Peroxide.—"The early users of zinc peroxide employed the dry powder, and an ointment with a vaselin base or a watery suspension. Our experiments seem to indicate that the liberation of oxygen and the production of hydrogen peroxide depend upon the presence of water. We have found that zinc peroxide is much more bactericidal in a water suspension than in oil. We have therefore applied it only suspended in sterile distilled water and have sealed the dressing so as to prevent evaporation.

"The powder is sterilized in conveniently small quantities of 10 to 50 grams in glass tubes. The contents of one or more tubes is then thoroughly mixed by means of an 'asepto' syringe with enough sterile distilled water to give an even creamy suspension about the consistency of 40 per cent cream. Effective material will usually be found to swell somewhat in the water so that it thickens; more water may have to be added during the course of the dressing. When the mixture is satisfactory it is spread over the surface of the wound with the syringe in such a way that it comes in contact with every part of the infected surface, particular care being taken to see that it gets under the undermined skin and down into the sinuses. It is frequently necessary to use a small catheter or a short tube to introduce it into the sinuses; this may be painful but it must be insisted upon, for the organisms will grow in any nook or cranny where the material has not been delivered. Strips of fine meshed gauze or silk are then dipped into the suspension and introduced into sinuses beneath skin flaps and on the surface until the whole wound is covered, including the normal skin margins. The whole area is then sealed with a double layer of gauze impregnated with vaselin or zinc oxide ointment. . . . This is prepared by placing the gauze and ointment in layers in an ice cream box of convenient size and autoclaving it so that the ointment permeates the gauze.

"The dressing should usually be changed daily but in painful cases it may be left for 2 days at first. The gauze covering is then lifted off and the old peroxide mixed with exudate is washed off with sterile water or saline solution The dressing is then reapplied.

"Clinical improvement is obvious within 3 or 4 days after treatment is begun; the exudate decreases and the granulations become firm and red, undermined flaps begin to seal down, and sinuses shorten. If there are any areas where adequate contact is not being obtained, they will show up as areas of activity in which the granulations remain grayish or greenish and the exudate continues to be profuse. Greater care must then be used to afford closer contact or the involved area may require further incision or excision Frequent cultures taken from various parts of the wound will give a check on clinical progress.

"When the wound is clean, both clinically and bacteriologically, skin grafts of the deep Reverdin type should be employed to hasten epithelization. These are held in place with a single layer of coarse meshed gauze sealed at the skin margin with collodion and covered with fine meshed gauze soaked in saline. This is sealed with vaselin gauze to prevent evaporation and after 24 hours the zinc peroxide dressing should be resumed, and the nnermost layer of coarse meshed gauze may be removed the following day."

The clinical use of zinc peroxide in ulcers due to the micro-aerophilic hemolytic streptococcus has received further endorsement from Shallow et al.,[232] and Lichtenstein[233] and in malignant lesions by Freeman[234] and Sunderland and Binkley.[235] Zinc peroxide in infected wounds in general has been praised by Gius,[236] Lewis,[237] Caldwell,[238] and Meleney and his associates.[239] Reid and Altemeier[240] have prepared an active peroxide ointment. A useful commercial zinc peroxide ointment is called "Perguent."

Bacteriophage.—After the independent discovery by Twort[241] in 1915 and d'Herelle[242] in 1917 of a transmissible agent causing the lysis of bacteria, there was much hope that a valuable means of combating wound infection would result.

Krueger and Scribner[243] in a report to the Council on Pharmacy and Chemistry of the American Medical Association, say:

"The reported data on the use of phage in various diseases caused by bacteria are for the most part insufficient to establish phage therapy as a method of choice. Only rarely have these studies included an adequate bacteriologic background, control groups or careful comparison with accepted therapeutic procedures. There is evidence, however, that a properly prepared lysate can serve satisfactorily as:

"(a) A vaccine for the treatment of certain diseases, e.g., some types of staphylococcic lesions.

"(b) An agent for the induction of nonspecific protein shock in syndromes in which at times such shock may be used to good purpose, e.g., typhoid.

"(c) A measure for enhancing the general resistance of an infected area when applied topically. This depends on its nonspecific action in mobilizing macrophages and microphages.

"It is equally evident that phage solutions possess no measurable degree of superiority over well known and accepted preparations employed for the same purposes; for example, bacterial vaccine and toxoid in carbuncles and furunculosis or typhoid vaccine in nonspecific protein shock therapy. Modern chemotherapeutic approaches to the treatment of a variety of conditions for which phage has been recommended (cystitis, pyelitis, gonorrhea, certain bacteremias) offer more chances of success than does phage.

"While it has become almost axiomatic to state that the use of phage is entirely innocuous, we have not found this to be the case. The literature provides numerous accounts of reactions ranging from mild to severe following the injection, local application or ingestion of phage, and animal experimental work has shown that lysates may contain enough soluble toxin or Raynal's spreading factor to be actually dangerous."

Plaster Casts.—Of recent years there has been an increasing appreciation of the value of rest in the treatment of contaminated and infected wounds by the success of the *closed plaster cast treatment.*[244] Fresh wounds are meticulously cleansed and débrided and then packed with vaselin; the extremity is enclosed in a plaster cast. This method insures rest and diminishes the trauma and the chances of cross-infection involved in frequent dressings. It also relieves pain and facilitates transportation. The pressure on the wound also may help in its healing.[245] D'Harcourt and his associates[246] recommend the encasement in plaster of all infected wounds after débridement and saucerization. In an excellent collective review of the management of open wounds as exemplified in World War II, Overton[247] says:

"Satisfactory results with the use of the closed plaster method necessitate the adherence to certain fundamental principles. The plaster must be applied directly to the wound surface and skin, without any other dressing or padding. The cast must not be changed too frequently, at not less than three-week intervals if possible. The occurrence of some systemic reaction with each change of cast is not an indication to remove it. The usual reaction is that of an elevation in temperature. This may go as high as 104 degrees but will gradually subside after a few days. During this period the patient will be in good general condition and there will be no undue pain or tenseness in the wound. Trueta warns that it is necessary to avoid premature removal of the cast because of discomfort, rise in temperature, and enlarged lymphatic glands, since all of these symptoms are but an expression of the intensity of the struggle which is taking place at the site of the wound. The making of a window, or, even worse, removal of the cast, will exacerbate the local infective process It is just the cases in which the cast is removed which are supposed to prove the advantages of antiseptic treatment and to discredit the closed plaster method. It is impossible to prove that the general infection which follows removal of the plaster is due only to premature surgical intervention; however, statistics show that if the cast is let alone, localization of the septic process will be established in nearly every case. If listlessness, a rise in pulse rate, intense pain in the region of the wound, and edema of the distal portion of the extremity accompany the rise in temperature, the cast must be removed and the wound examined. At this time it will usually be found that the treatment prior to the application of the cast had not been complete in that adequate drainage had not been established This condition must be combated by re-establishing free drainage, carefully repacking the wound, and reapplying the plaster."[248]

Rest.—*Infected wounds must be put at rest.* An infected wound of the skin over an interphalangeal articulation of a finger should be splinted with a small tongue depressor splint. Likewise, infections of the extremities require splintage and elevation.

If the purulent discharge has reached a minimum and the wound secretion is of a glairy mucoid type, it is often wise to begin measures to approximate the wound edges. This is most conveniently done by using strips of adhesive plaster which are not placed so closely together as to bar the exit of wound secretion.

Occasionally, infected wounds may be accompanied by such complete disorganization of the soft parts that amputation becomes necessary. Amputation, however, should be considered only as a life-saving measure when it is evident that the extremity cannot be saved.

Patients with infected wounds should be made as comfortable as possible. If the pain is severe, capsules consisting of 5 grains of aspirin and ½ grain of codeine are very efficient and may be given as often as every four hours. Fluids should be pushed.

Closed Infected Wounds.—*Symptoms.*—The symptoms of pyogenic infection in closed or sutured wounds consist of increasing pain, which is of a throbbing character and synchronous with the pulse beat, swelling and redness about the wound margin. The temperature may be elevated, and leukocytosis is not uncommon. In open wounds the first and chief sign of infection is a purulent discharge. There may also be the other signs which are found in closed wounds, such as pain, redness and swelling. The symptoms of an acute spreading infection are redness, swelling, malaise, fever and *red streaks running up the extremity.* (See Lymphangitis.)

Treatment.—Sutured or healed wounds which show signs of infection require prompt treatment. The wound should first be reopened with a probe, scissors or divulsing hemostat at the point of maximum inflammation. The opening should be continued until the extent of the infected area has been exposed. The pus, if present, will then be evacuated, and the abscess cavity, if present, may be irrigated with a warm boric acid or dilute iodine solution. A drain then should be inserted which is made of rubber, Penrose tubing or gauze, and if necessary the wound edges should be loosely packed to prevent the premature approximation of the skin edges Warm boric acid fomentations then should be applied, or the wound should be treated by irrigations with Dakin's solution, and after this the physician should proceed as in the case of infected open wounds to be described below. *Acute spreading infections are never incised or traumatized in any way* They are always treated by continuous warm fomentations. Sulfonamides and penicillin should be administered. (See sections on Sulfonamides and Penicillin.)

SPECIAL INFECTED WOUNDS

Tetanus.—Tetanus is an infectious disease caused by the tetanus bacillus. It is characterized by painful tonic contractions of the muscles The muscles of mastication (the masseters and the pterygoids) are most commonly involved (Stone). This organism grows best under anaerobic conditions. It may be found in earth, garden mold and manure and is normally present in the intestines of many ruminants, horses and herbivora. The spores survive easily outside the body and are extremely resistant to the methods commonly employed to kill pathogenic bacteria.

Bauer and Meyer[249] found that 24.1 per cent of 530 specimens of human stools contained tetanus spores. Meyer and Spector[250] state that the stools of healthy individuals not infrequently contain tetanus organisms and that "the incidence of healthy carriers

of the Bacillus tetanus is relatively high among the rural population and relatively low among the urbanites (1 per cent in Chicago)." Gilles[251] undertook an investigation to determine the presence of tetanus spores in street dust. He concluded that the positive results gave definite and conclusive proof that Clostridium tetani is widely distributed in street dust even at the present day and established the absolute necessity for the use of prophylactic injection of tetanus antitoxin in all cases of street accidents accompanied by laceration or abrasion of the cutaneous surface. The fear of anaphylaxis can no longer justify failure to employ protective serum in every case of street accident in which there are open wounds, since street dust, contrary to the views of many, has been shown to be a potential source of danger. Among the British wounded during the early part of World War I, 15 to 32 of each 1000 had tetanus, but after routine injection the incidence was reduced to 1 to 3 per 1000 (Stone). Of the 24,089 American wounded, there were only 36 with tetanus, or 0.16 per 1000. (See section on Tetanus Toxoid.)

The incubation period is only a few days in the acute cases but may be four or five weeks in the chronic cases. Antitetanic serum prolongs the incubation.

Hogenauer[252] reports a case of cured tetanus in which, when a splinter of wood was removed from the forearm two and one-half months later, virulent tetanus bacilli were found upon it. Ernst[253] reported a case in which the patient sustained injuries of the left hand in the explosion of a dynamite bomb in 1916. In 1931, six days after contusion of the same hand, severe tetanus developed. In the cleaning of the wound, small pieces of pasteboard in which tetanus bacilli were demonstrated on bacteriologic examination, were removed. It could not be determined whether a prophylactic injection of serum had been given immediately after the injury. Dimtza[254] reports 2 cases of leg ulcers in which tetanus bacilli were found. The first patient showed a stormy course of tetanus and died suddenly, while in the second patient the tetanus bacilli were incidentally discovered in the scabs and purulent discharge of the ulcer, but there were no signs of tetanus infection. Fatal cases of tetanus have occurred after aseptic operation on the plantar surface of subjects who had gone barefoot.[255] Tetanus has been reported following an induced abortion,[256] from pressure caused by a T splint for fracture of the clavicle,[257] from an ulcerating cancer of the breast as a portal of entry,[258] and following an operation for talipes in a person from a rural district.[259] Welch and his associates[260] point out that sulfanilamide powder may contain tetanus spores and should be sterilized before being used in wounds. Vener and Bower[261] have reported two attacks of tetanus in the same person with recovery. Jahier[262] has reported three cases of fatal umbilical tetanus in the rural districts of Algeria. Hall[263] reported that out of a total of 2493 civil contaminated wounds there were 11 in which Cl. tetani was recovered from the débrided tissues.

The danger of tetanus infection is ever present and cannot be too seriously considered. Tetanus infection has occurred following an abraded wound of the forehead caused by a fall in the street with the ill advised application of collodion.

There are approximately 1500 deaths from tetanus annually in the United States (1253 in 1933, according to Klopp[264]). Calvin and Goldberg[265] studied 183 patients with tetanus treated at the Cook County Hospital, Chicago, over thirteen years. They found that the average mortality for the years 1917 to 1921, inclusive, was 56.4 per cent for 44 cases, and for the years 1925 to 1929, inclusive, it was 73.2 per cent in 85 cases. The disease occurred five times as commonly in males as in females. In their series, tetanus following gunshot and powder wounds had a high mortality (95 per cent) and following lacerations a relatively low mortality (44 per cent). In puncture wounds the mortality was about midway between the two. If the patient survived the first three days of the disease, the chances of his recovery were much greater. They say that "the high mortality of tetanus in spite of specific therapy emphasizes more strongly than ever the tremendous value of prophylactic inoculations in any cases of injury in which tetanus is even remotely liable to develop." Karnit-

schnigg[266] studied 34,314 injuries. Tetanus antitoxin was administered in 16,269 of the cases and was omitted in 18,045. In none of the patients subjected to the serum treatment did the disease develop, while in the latter group there were 29 cases of tetanus with 12 fatalities. Vinnard[267] reported 352 cases of tetanus, with a total mortality of 45 per cent. Hoge[268] reported finding Cl. tetani in 12 of 267 severe burn cases and said he believed the actual incidence was much higher. None of the patients in the series had symptoms of tetanus. Cross[269] reports that in Illinois in the fifteen year period from 1930 to 1944, inclusive, there were 732 cases of tetanus, with 561 deaths, a mortality of 76.6 per cent[270] It is not unlikely that the Chinese have some immunity to tetanus because of their environmental exposure.[271]

Graves[272] studied 813 cases of tetanus at the Charity Hospital, New Orleans, and makes the following pertinent comment:

"That the prophylactic use of antitetanic serum lowers the mortality rate in those who develop tetanus is well established, but it probably is not generally appreciated that the

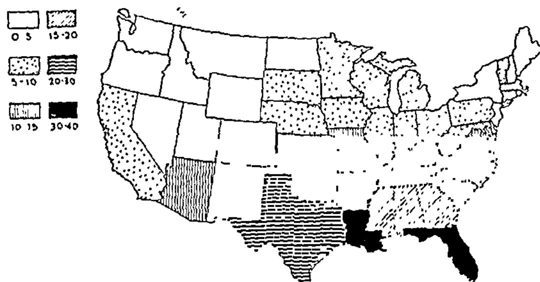


Fig. 22.—Average annual deaths from tetanus per million population based upon the years 1933, 1934, and 1935 and the official 1930 populations. (Moore, R. M., and Singleton. A. O.: Surg., Gynec. & Obst. 69: 146, 1939.)

... important than the ...

be performed on all wounds in which there is a possible contamination ... and in most cases the wound should be left wide open and drainage not hindered by the application of a tight bandage."

Wounds of the lower extremities cause more cases than those in other parts of the body, but the mortality is the lowest. Rhoads[273] says:

"During the eight years I was in charge of the Nurses' Infirmary at Cook County Hospital, there were two cases of tetanus, both fatal. The first was a nurse who received a slight laceration above one eye when she was thrown against the mirror in the front of an automobile. She was taken at once to a surgeon at the Cook County Hospital. The laceration ... Because of the minor character ... though ... y when ... r gland

she returned for a dressing ...

was felt in front of the ear. A prophylactic dose of tetanus antitoxin (1500 units) was given and she was hospitalized for hot dressings to the lesion. The following day she had typical tetanus. In spite of large doses of tetanus antitoxin administered intraspinously and intravenously she died one day later.

"The other patient was a nurse who received a slight puncture wound in her knee while at a bathing beach one evening. She thought the injury was from a wire which lay beneath the surface of the water. She reported to the Infirmary next day. The usual prophylactic dose of tetanus antitoxin (1500 units) was given, and hot boric packs advised. The lesion did not heal as promptly as was expected. Two days later the girl was hospitalized. Seven days after the injury another prophylactic dose was given. Two days later she developed typical tetanic convulsions, and in spite of intensive serum therapy, within twenty-four hours was dead.

"In the two cases just cited, in addition, possibly, to inefficient local débridement of the wounds, there was an insufficient appreciation of the quantitative character of immunity against tetanus. Not enough prophylactic antitoxin was given. In the first case the importance of the delay in administering the antitoxin was not sufficiently realized."

Tetanus Antitoxin.—In certain types of wounds, no judgment whatsoever is required to decide upon the administration of tetanus antitoxin. Meticulous surgical excision of wounds will decrease the incidence of indications for tetanus antitoxin. Rhoads quotes Hanke,[274] who in turn cites Mosbacher, who collected reports of 2031 cases of tetanus which developed after the early administration of tetanus antitoxin (in 745 cases the injection was given within twelve hours after the injury). The highest mortality rate in Graves' series of common wounds was from nails. "Prophylactic doses of antitetanic serum lower the incidence of tetanus and lower the mortality rate in those that develop tetanus" (Graves). He believes that the antitetanic serum should probably be given every seven days as long as there is a possibility that tetanus infection may develop. Raul and Nerson[275] report a case of tetanus limited to the lower portion of the legs. Other cases of localized tetanus are reported by Green.[276] Kovtunovich and Chernaya[277] demonstrated in experiments on guinea pigs the importance of treatment of the wound in the prophylaxis as well as in the active treatment of tetanus. The tetanus bacillus is an anaerobe that is particularly sensitive to oxygen. Wounds contaminated with the bacillus heal readily, since they do not cause suppuration and have but little proteolytic effect. Timely injection of antitetanic serum is a real prophylactic measure, but the authors emphasize that it is capable of neutralizing only that toxin which is not bound to the nervous tissue. Furthermore, it is rapidly eliminated. For this reason a second prophylactic injection, from seven to eight days after the first, is recommended. The serum has no bactericidal effect against the bacilli themselves. For this reason the authors consider early treatment of the wound the most important prophylactic measure against tetanus. Their animal experiments clearly demonstrate that prophylactic injection of serum alone is not effective in preventing tetanus. They therefore recommend that every wound suspected of harboring foreign material be widely opened under general anesthesia, that foreign bodies and dead tissue be removed and that the wound be left wide open. In wounds so treated, tetanus almost never develops. Ehalt[278] rejects tetanus prophylaxis when all the lacerated and bruised tissue can be excised. He uses antitoxin in puncture wounds of the feet and in other wounds which cannot be excised.

If indicated, tetanus antitoxin should be given at once, certainly within the first twenty-four hours.[279] Remertz[280] said that "after a lapse of one hour in experimentally infected animals, 24 times as much antitoxin is required to

preserve the animal as is required when the antitoxin is given at once." The customary prophylactic dose of tetanus antitoxin is 1500 units. Rhoads[281] believes that 3000 units should be given routinely except for the most trivial wounds and sometimes more. Lockwood[282] gives the following advice:

"Tetanus antitoxin, 3000 units, should be given after preliminary test of sensitivity, accompanied by 1 cc. of tetanus toxoid (to be repeated on the eighteenth and thirty-ninth days). However, if the individual has already received a full course of toxoid immunization, only 1 cc. of toxoid need be given." In cases of blank cartridge wounds and gunshot wounds tetanus antitoxin should be given.

The sole of the punctured shoe is always a potential source of tetanus infection. A puncture wound of the foot caused by a rusty nail in the garden or the prong of a rake furnishes the etiologic basis par excellence for tetanus. Of course no one fears the rust, which is merely oxidized iron on the nail, but the presence of rust generally indicates that the nail or other instrument has been lying about outdoors and may have been in contact with the soil. A nail which has been withdrawn from a partition or which has lain exposed to the sun or open air, as on a roof or in a lumber pile, is very unlikely to have on its surface Cl. tetani. In wounds sustained by bathers who step on pieces of glass in the water or on the beach tetanus may develop. Many surgeons are extremely hesitant in the administration of tetanus antitoxin because of the likelihood of anaphylactic reactions and place their main line of treatment upon excision or very thorough incision and carbolization of the wound. Lecène[283] considers early excision of the wound of inoculation to be of prime importance.

An unusual source of tetanus was reported by Urech.[284] Two months after a cast had been applied to a young man for ankylosis of the knee, he was readmitted with tetanus. An abrasive wound was found over the inner condyle of the femur. From the straw packing which had been used between the cast and the skin, cultures were made which caused the death of guinea pigs from tetanus in three days. The patient recovered after the administration of tetanus antitoxin.

General surgeons are more prone to use tetanus antitoxin than are industrial surgeons, who consider tetanus rare in their field. Campiche[285] considers the possibility of soil contamination to be the most important aspect of the problem. Vinnard[286] reported 269 cases of tetanus due to trauma. The distribution of the types of injuries in his cases (from the Charity Hospital, New Orleans) are shown in the accompanying table. He says:

"Of the 101 puncture wounds, 71 were from nails, 7 unknown, 5 tacks, 5 bone, 3 pins, 2 wires, 2 pitchforks, 2 rakes, 1 ice pick, 1 needle, 1 shoe nail, 1 steel tong. Of the 69 splinters, 58 were wood, 3 thorns, 2 steel, 1 soybean barb, 1 weed, 1 bone, 2 shells, and 1 unknown. Of 54 lacerations, 18 were caused by unknown objects, 16 by glass, 4 brick, 3 tin, 2 shell, 2 cement walks, 2 knives, and 7 miscellaneous. The ages of the patients in this group ranged from a few months to 74 years. It is very evident that no age or class of people is immune and that no injury is too trivial to cause tetanus."

Bowen[287] gave tetanus antitoxin to 661 patients with nail puncture wounds, with no deaths and no cases of tetanus. Tetanus antitoxin was given in 220 cases of puncture wounds by Walker[288] and in 445 cases of puncture wounds by Kerrigan.[289] McDonnell et al.[290] treated 721 men for nail puncture wounds without a case of tetanus. Antitoxin was given in 54 per cent of the

Wound	Number of Cases of Tetanus	Average Incubation Period (Days)	Deaths	Per cent
Puncture	101	12.7	50	50
Splinter	69	10.2	30	43
Laceration	54	11.9	26	46
Scratch	11	7.2	5	45
Abrasion	16	9.0	6	38
Burn	3	20.0	1	33
Bite (1 dog, 1 rat)	2	30.0	1	50
Compound fracture	3	11.7	3	100
Crushing	3	14.7	1	33
Amputation of finger	2	10.0	0	..
Multiple	4	....	1	25
Abscess	1	5.0	0	..

cases. "It was used when punctures were exceptionally deep or showed gross contamination or signs of infection." This would seem to be rather insecure guidance. The technic of their local treatment was as follows: "(a) cleansing the outside of the wound, (b) trimming skin flaps and wound edges, (c) probing to the bottom of the wound, (d) irrigating with antiseptic solution from the bottom of the wound—hydrogen peroxide solution recommended, and (e) dry, sterile dressing."

In the borderline cases it is extremely difficult to make a decision, and the patient or the parents of the patient should be acquainted, as nearly as it is possible to do so, with the probabilities and the dangers and should be invited to share some of the responsibilities in making the decision. Once it is decided to give tetanus antitoxin, the patient should most carefully be interrogated as to the possibility of having horse serum sensitization. He should be asked: "Have you ever had diphtheria?" "Have you ever been given antitetanic serum?" "Have you been given any serum?" "Do you suffer from asthma?" "Do you sneeze when you are near horses?" In the event that the patient is likely to be sensitive to horse serum, and antitetanic serum is urgently indicated, one must proceed with great caution. It is well to dilute the antitetanic serum, 1:200, and inject 1 or 2 drops of the dilution *in* the skin. If no severe reaction ensues, one may cautiously proceed with the balance of the injection.

The conjunctival test is of value according to Mackenzie and Hanger[291] but is disapproved of by some ophthalmologists. In this test, 1 drop of a 1:10 dilution of the serum is instilled in the conjunctival sac. Hyperemia, swelling, itching or pain in about fifteen minutes indicates a positive reaction. A few drops of epinephrine can be used to protect against corneal damage. This test is less sensitive than the intradermal tests so will not exclude a pseudopositive reaction.

If a reaction occurs, the patient will have to be desensitized. This may be done by very gradually increasing the dose until the entire amount has been given.* In 941 prophylactic injections of tetanus antitoxin, Thomas[293]

* The Besredka method of desensitization consists of the injection of 1 cc. of a 10 per cent dilution of the antitoxic serum, followed after four [illegible]
afte [illegible]
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noted the occurrence of general reactions in 3.3 per cent. In 943 cases in which 5 minims of epinephrine was given with each dose of antitoxin, there was only one general reaction, or an incidence of 0.1 per cent. Mackenzie and Hanger[291] have made a study of this, and their observations include the following:

"Serum accidents may be mild or severe. They may appear after an interval of a half an hour or even before the needle is withdrawn. Two groups of persons are subject to such a reaction. One group are those known as 'horse asthmatics,' who suffer from asthma or rhinitis when exposed to horse dander. Among these may be found some who give a positive skin test to horse serum, but who have never had asthma. The other group is made up of persons who have become sensitized to horse serum through previous serum treatment. While a percentage of those given toxin-antitoxin immunization may give a positive skin reaction for serum, the danger of serum sickness is not great and no deaths have been reported from such circumstances. It has been shown, however, that persons given a therapeutical dose of serum usually become sensitized and reach a dangerous degree of sensitization. All available records show but a small number of fatal results.

"Persons sensitive to horse serum may be identified from a history of asthma or allergic rhinitis. A history of previous serum treatment should put the physician on his guard. In all suspected cases a skin test consisting of an intradermal injection of 0.05 cc. of a 1:10 dilution of the serum should be made. If the reaction is positive at the end of one-half hour, there is an increase in the size of the injection wheal with an area of erythema about it. The projection of pseudopods from the wheal denotes a high degree of sensitivity. The conjunctival test is also of value.

"In man, desensitization cannot be obtained with the promptness with which it can be obtained in laboratory animals. In the presence of a strongly positive skin test, the first injection of serum should be made subcutaneously and should not exceed 0.01 cc. If no untoward symptoms occur, the dose may then be doubled every thirty minutes until 1 cc. is given. After the usual interval, if no reaction is noted, 0.1 cc may be given intravenously. At intervals of twenty minutes this dose may be doubled until the required amount of serum is given. Epinephrine should always be at hand to control a possible reaction and should be used repeatedly when needed. It is a good rule never to make the first intravenous dose of serum more than one tenth the last subcutaneous dose."

State and Wangensteen[294] investigated the effect of intravenous procaine in the treatment of delayed *serum sickness*. Their conclusions, in part, are as follows:

"One Gm. of procaine diluted with 500 cc. of saline solution administered over a two hour period has been given to 27 patients without untoward reactions. Ten of the 16 patients with serum sickness following the injection of bovine albumin obtained complete relief and an additional 4 temporary relief after the intravenous administration of procaine. Two were not benefited. The rather striking relief noted in the case of serum sickness following the use of tetanus antitoxin suggests that procaine may prove extremely useful in the management of serum sickness attending the use of tetanus antitoxin. . . . Procaine must be administered at too slow a rate to make its use feasible in severe immediate anaphylactoid reactions. Epinephrine remains the drug of choice in such circumstances. . . . The exact mode of action of procaine in the treatment of serum sickness and sensitive states is not known" A successful result in the treatment of delayed serum sickness due to tetanus antitoxin by intravenous procaine is reported by Appelbaum et al.[295]

Bennett[296] reports 5 cases of horse serum neuritis. "The prognosis for recovery within six months is usually good, but about 20 per cent of the patients are left with residual weakness and atrophy."

It must be remembered that rarely "a child or an adult, receiving an injection of horse serum for the first time, dies in acute anaphylactic shock or manifests grave accelerated allergic reactions."[297]

Schaer[298] states that anaphylactic shock with death occurs once in 50,000 *injections* He suggests the following measures for the prevention of serum sickness:

1. The use of serum from a different species (bovine serum) for reinjections.*

* Now obtainable commercially in the United States

2. Desensitization by the method of Besredka and the use of intracutaneous tests. If [illegible]

Serum sickness occurs in about 10 per cent of the cases in which commercial vaccine is used in Switzerland.*

Park[300] states that 1 death occurs for every 70,000 persons given diphtheria antitoxin. Ratner[297] says that only such individuals as are shown to be sensitive to both horse dander and horse serum should be regarded as risks for the primary administration of horse serum. If it should be imperative to administer horse serum for therapeutic purposes, the greatest precautions should be observed to give the serum exceedingly slowly and by the routes of least absorption, coupled with the utilization of such drugs as epinephrine and atropine.

According to Owen,[301] some 20 cases of multiple neuritis have followed the prophylactic injections of tetanus antitoxin.[302]

Bovine Antitoxin.—Persons who are sensitive to horse serum usually may be given bovine serum. Glaser's[303] experience with 38 cases in which bovine tetanus antitoxin was used has been summarized as follows:

1. Bovine tetanus antitoxin has been used with safety in selected cases known to give severe anaphylactic reactions to horse serum. 2. The only indication for the use of equine tetanus antitoxin is for patients who are known to be, or can be demonstrated to be, sensitive to the bovine but not to the equine preparation. 3. Persons undergoing study for allergy should be tested routinely with equine and bovine serum. This should be done by the scratch method only, to avoid as far as possible sensitizing the patient to the serum. If the patient is sensitive to both serums he should be immunized by tetanus toxoid.

Tetanus Toxoid.—One of the most dramatic accomplishments in World War II was the practically complete elimination of tetanus by immunization of the soldiers with tetanus toxoid. In the American Civil War the incidence of tetanus was 2 per 1000 in 246,712 wounds, but the mortality reached the staggering figure of 89.3 per cent. In World War I during the first three months, the incidence in the British forces was 15 to 32 cases per 1000, with a mortality of 57.7 per cent. After routine administration of antitoxin serum, the incidence fell to 2 to 3 per 1000 wounds, with a mortality as low as 15 per cent.[304] In the American Expeditionary Forces the incidence was 0.16 per 1000, "a low incidence attributable to prophylactically administered antitoxin and probably also to the fact that no large numbers of these soldiers fought over chalky and manured fields of the Somme region."[305] The incidence of tetanus among 33,027 Polish wounded in World War II was 0.66, with a mortality of 53.5 per cent. The incidence of tetanus in the British troops evacuated from Dunkirk was 0.45 per 1000. In the small percentage of wounded unprotected by immunization, there were 8 cases of tetanus, while among the large proportion of patients who were actively immunized (16,000), there was not a single case of tetanus.[306] Among the American wounded at Pearl Harbor, there was *not a single case of tetanus.* Almost every wounded man there had previously had prophylactic injections of tetanus toxoid and was given a "booster" injection on the same day or soon after the initial attack on Dec. 7.[307] Tetanus antitoxin was given to the few patients who were not definitely known to have had the toxoid.

* For serum shock and serum sickness following use of antitetanic serum, see also Rackeman.[299]

After the work of Ramon,[308] all French soldiers and all the horses of the French army were given tetanus toxoid.

Firor[309] says: "The most important feature of active immunization by tetanus toxoid is that once a patient has had the three subcutaneous injections, at properly spaced intervals, he is apparently prepared so that at any subsequent time, a fourth injection will rapidly raise the titer of antitoxin in his serum to a level which is absolutely capable of protecting him from tetanus. This ability of the patient to respond quickly to a fourth injection is known to exist at least five years after the preparatory course was given. It is likely that it exists throughout the life of the patient, but one cannot be certain of this point. Furthermore, the response to the fourth or to subsequent inoculations is so prompt that no antitoxin need be given."

In a later paper Firor says:[310]

"Two kinds of tetanus toxoid have been prepared, the plain and the alum precipitated. In the United States, standards for the potency of each have been set by the National Institute of Health. Most investigators have felt that the alum precipitated produces a better antitoxin response in the patient. The method of administering tetanus toxoid is as follows:

"An initial dose of 1 cc. is given subcutaneously. In most instances this produces no appreciable amount of antitoxin. At an interval of from one to three months later a similar injection is given, and within ten days there is detectable antitoxin in the blood. The amount of this antitoxin is practically always sufficient to protect against an ordinary infection. If, however, a third injection of toxoid is given at an interval of from one to three months, the titer of antitoxin in the blood rises rapidly and persists for months. The exact period for which protection is afforded by three injections of toxoid is not accurately known because this substance has not been available long enough. Numerous authors have reported the presence of appreciable amounts of antitoxin in the blood of patients months after a basic course of toxoid had been given." Gold[311] reported the following data on the presence of antitoxin in patients who had received two injections of alum precipitated toxoid: "After three months 92 per cent of the patients showed at least 0.1 of a unit of antitoxin; after six months 71 per cent showed a similar amount, and after a year 56 per cent; after two years 30 per cent still had 0.1 of a unit of antitoxin." Gold has shown that after two subcutaneous injections, in lieu of "repeat" injections, intranasal instillations of tetanus toxoid topagen (0.1 cc. dropped in each nostril on three successive days) can be given with advantage and repeated every six to twelve months. "They will then produce a solid immunity against tetanus."[312] Miller and Humber[313] say that "using tetanus antitoxin production as a measure of potency, alum precipitated tetanus toxoid has been found superior to fluid tetanus toxoid. Higher titers of antitoxin are produced and are maintained longer after the former preparation . . .

"Three injections of alum precipitated tetanus toxoid at 3 monthly intervals initiate and maintain for 1 year high antitoxin titers, between 0.1 and 1.0 unit This level is probably protective even if reinjection is impossible or is omitted because of parental negligence at the time of trauma. Two injections of alum precipitated toxoid do not result so regularly in the maintenance of such high titers for a year. A basic course of 3 injections and annual reinjection with alum precipitated toxoid are therefore recommended for children.

"When laceration occurs in any individual previously injected with either alum precipitated or fluid tetanus toxoid, a stimulating reinjection with fluid tetanus toxoid is to be preferred to one with alum precipitated toxoid because the desired rise in antitoxin is more rapid."

He also says:[310] "All of the early workers in the field of active immunization against tetanus reported either no reactions or an exceedingly small percentage. For instance, Whittingham[314] reported that only 14 reactions of any kind were noted following the [illegible] of 61,000 soldiers. Two of these 14 reactions were anaphylactic and 12 were [illegible] rticaria occurring in 1700 patients [illegible] summer of 1941, however, an altogether unexpected outbreak of severe reactions appeared. In some places the incidence was as high as 25 per cent. These reactions followed the injection of both the plain and the alum-precipitated toxoid and occurred after the first as well as after subsequent injections. An intensive study was undertaken to determine the cause of this unfortunate occurrence. It has become increasingly clear that the use of Witte or Berna peptone in the media growing the Clostridium tetani was responsible for these reactions. Whenever

Martin's peptone has been used for producing toxin and subsequently toxoid, few if any reactions have occurred. The technique of Brewer provides a highly potent toxin practically free from proteins."

Unger[316] says that the presence of allergy is no contraindication to the use of toxoid. He gave 291 injections of tetanus toxoid to 171 allergic patients, with local reactions in 23 cases and no general reactions. These patients are instructed to receive tetanus toxoid in the event of injury rather than tetanus antitoxin.

Combined immunization against tetanus and diphtheria by two injections of 1 cc. of the combined toxoids or three injections of 0.5 cc. is now possible and widely employed. If the interval between injections is three months or more, the response of the antitoxin is enhanced.[317]

The treatment of tetanus once it has developed is not properly considered in the field of minor surgery.[318]

Gas Gangrene.—Gas gangrene is due to the presence of anaerobic organisms, chiefly Clostridium welchii, the vibrion septique, B. oedematiens, and B. sporogenes. The propagation of these organisms in the anaerobic medium of the deep tissues brings about the formation of gas bubbles which are spread longitudinally in the muscle fibers and along the fascial planes. This is accompanied by necrosis of the tissue involved and by extreme toxemia.

As pointed out by Kenning,[319] gas bacillus infection may occur in any of three types of wounds, viz.: "(1) Crushing injury with rupture of the skin. (2) Puncture wounds with excessive bloody extravasation. (3) Laceration with extensive tissue damage. Under these heads may be classified gunshot injuries, shrapnel and shell wounds, compound fractures contaminated with soil or street refuse, crushing injuries of the street, or injuries from high explosives."

Boland[320] reports the development of gas gangrene in 15 (19 per cent) of 80 Negroes with compound fractures at the Emory University Division of the Grady (Municipal) Hospital, Atlanta, Ga. Mitchell, Bryant and Chapman[321] found 135 indisputable cases of gas gangrene infections in New York state hospitals of 50 beds or over in a period of five years (1932 to 1936, inclusive). They believe this infection is probably as frequent as tetanus. Eliot and Easton[322] reviewed 17 cases at the Knickerbocker Hospital in New York. They recognized the following types of cases: "(1) Localized anaerobic infection of the wound, (2) slowly spreading anaerobic infection of the wound, (3) gas gangrene of the 'group type,' wh[illegible]
of the massive type, w[illegible]
type, where an overw[illegible]
eight hours." Gerl[illegible]
well as rural d[illegible]
Berlin streets. [illegible]
from the Berli[illegible]
were latent for a period of fifteen years in the leg of a man who was wounded during the first World War; fatal gas infection developed after a bone operation. Gas gangrene has occurred where there is no wound;[326] as a complication of laparotomy incisions,[327] *hypodermic injections*,[328] and following clean amputations.[329] It has been found in leg ulcers,[330] and has caused panophthalmitis following a wound of the eye by a steel fragment.[331] Harney[332] says that 86 cases of gas gangrene following therapeutic injections have been reported, with a mortality of 88.4 per cent. Saegesser[333] says that recent investigations have proved that gas gangrene bacilli may remain alive in 70 per cent alcohol as well as in the hypodermic syringes stored therein. The files used for opening ampules have also been known to harbor gas gangrene bacilli.

Any patient who has had a deep, dirty wound with traumatism of muscles should be watched for the appearance of gas gangrene. Maes[334] stresses the importance of suspecting gas gangrene infection in any wound involving

muscle which has been contaminated by wool (clothing, even though clean) or soil. The average patient has a moderate elevation of temperature and a pulse curve which is elevated out of proportion to this temperature. He has a maintained and even accelerated intelligence and but a moderate amount of pain. The wound itself may show a watery discharge, and smears from it may show the Clostridium welchii.* Often a characteristic odor may be noted. The area about the wound is swollen, and crepitus may be elicited; commonly a site far distant from the wound of entrance may be affected. The writer has seen gas gangrene of the buttock occur secondarily to a wound of the wrist. The affected area is always swollen, and the elicitation of crepitation is pathognomonic. The gas bubbles may be seen in the *x*-ray film.

Brailsford[337] says: "In the penetrating wound, gas bubbles around the foreign body will be the first indication of anaerobic infection: but wood splinters, clothing, and other materials of this density in or by which the organisms were introduced will not be revealed by x-ray, so the bubble may be the only evidence of the presence of foreign material. There is no other condition capable of giving rise to radiographic appearances similar to those of this acute fulminating gangrene, but it should be noted that the isolated gas bubbles may be simulated by the bubbles produced by irrigation with peroxide." The early diagnosis of gas gangrene has been discussed by the author in a previous publication.[338]

Surgical treatment is important in the prophylaxis. Böhler[339] considers surgical prophylaxis of more importance than serologic prophylaxis. All devitalized tissue about wounds should be carefully removed with a sharp knife. Jagged edges and skin which obviously is doomed to pressure necrosis should be removed at the original treatment of the wound, care being taken that none of the vital structure is injured. The writer agrees with Böhler[339] that the use of strong antiseptics is injurious to the tissues. Meleney[340] says: "If the signs are unmistakable or if, in doubtful cases, large gram-positive bacilli are numerous in the smear, immediate operative intervention is of utmost importance. This procedure should not wait for the cultural determination of the organisms. The wound should be completely excised, and all foreign bodies and necrotic tissue should be removed. Individual muscles should be explored and any inactive or devitalized muscle tissue removed. When all the involved muscle that can safely be removed surgically has been excised, the wound should be flooded with a creamy suspension of sterile (Du Pont's medicinal grade) zinc peroxide (now distributed by both Merck and Mallinckrodt) in sterile distilled water and then packed lightly with gauze or absorbent cotton soaked in this material. This in turn is covered with a thick layer of cotton soaked in distilled water. The whole dressing is sealed with petrolatum gauze to prevent evaporation. This dressing should be changed daily until the anaerobic organisms have disappeared from the wound. If the disease is diagnosed soon after its development, amputation usually is not indicated unless there is a compound fracture."

Active studies are being made to prepare a gas gangrene toxoid which will be as effective as tetanus toxoid.[341]

After thorough débridement in cases of suspected gas bacillus infection, the Surgeon General[342] recommended the following:

"(a) Prophylaxis: (1) Chemotherapy: Sulfanilamide at present is recommended as the drug of choice. Initial dose (oral): 6 0 grams. Subsequent doses: 1.0 gram q. 4 h. day and

* For rapid identification of Clostridium welchii in accidental wounds, see Altemeier[335] and Butler.[336]

night. This should be continued for seven days or until definitive treatment is available. This period of therapy almost always eliminates the possibility of gas bacillus infection. Crystalline sulfanilamide should be used *locally*. It should be distributed evenly over the surface of the [illegible] inch but not over 10 grams for any [illegible] it gas gangrene antitoxin when in [illegible] Dosage: Polyvalent gas gangrene antitoxin 11,000 units.

"(b) Treatment: (1) Chemotherapy: *Sulfathiazole:* Recommended *at present* as the [illegible] 1.0 gram q. 4 h. day and [illegible] 1.5 gram q. 4 h. day and [illegible] herapy: Crystalline sulfa- [illegible] istributed evenly over the [illegible]

considered high. However, the severe nature of the infection warrants heavy dosage and local absorption from open surfaces is variable depending on the amount of tissue fluid present, as well as other factors. In the hands of some, the local use of zinc peroxide has proved efficacious. If all grossly infected tissue appears to have been removed, a paste of zinc peroxide may be applied. This is made by mixing a medicinal grade of zinc peroxide with an approximately equal amount of sterile distilled water or physiologic saline solution, to form a smooth, creamy suspension, which flows readily to all parts of the wound. The wound is then covered with a thick layer of cotton, wet with water or saline solution, over which is placed a layer of rubber, cellophane, or vaseline [petrolatum] gauze, to prevent evaporation. A fresh dressing should be applied every one or two days, washing out the exudate and old zinc peroxide with sterile physiologic saline solution. These dressings [illegible]

is indicated. Therapeutic dosage: 20,000–40,000 units or more intravenously, supplemented, if need be, by intramuscular injections. These doses may be repeated in from 12 to 24 hours depending upon the symptoms and the response of the patient to the initial dose."

The local implantation of sulfonamides in wounds as a preventive of gas gangrene has received strong endorsement. Reed and Orr[343] conclude:

"Experimental gas gangrene in guinea pigs inoculated with Cl. welchii, Cl. septicum, [illegible]

therapy. Those caused by Cl. septicum and Cl. novyi are somewhat more resistant and those caused by Cl. sordellii much more resistant to chemotherapy. With reference to the group of causative organisms as a whole, sulfanilamide and six derivatives tested may be arranged in the following order of increasing effectiveness: sulfanilamide, sulfacetamine, sulfanilylguanidine, sulfapyridine, sulfamethylthiazole, sulfadiazine and sulfathiazole. Local treatment is superior to oral treatment. The difference is marked with the less efficient drugs and less marked with the most efficient drugs." In a later paper[344] these authors state that they found chemotherapy with sulfathiazole or zinc peroxide alone to be more effective in experimental animals than when combined with plaster immobilization. Sandusky and Meleney[345] found that when used in experimental wounds in animals "within two hours after productior [illegible] and the sodium salts of th [illegible] gangrene in animals whose [illegible] The effectiveness of zinc peroxide in such wounds has not been convincingly demonstrated [illegible] salts are more effective in [illegible]

Reed and Orr[347] found that "introduction of zinc peroxide into wounds in guinea pigs inoculated with ten lethal doses of Cl. welchii, Cl. septicum, Cl. novyi or Cl. sordellii results in a high percentage of recoveries and in a prolongation of the survival time in case of fatal infection. In the treatment of wounds in which the gas gangrene infection was established before therapy was initiated, zinc peroxide was slightly less effective than sulfathiazole."

Holzworth[348] found zinc peroxide to be a valuable adjunct in the treatment of gas bacillus infection.

The surgical treatment of well developed gas gangrene consists in the removal of all of the devitalized tissue and the provision for adequate drainage of all tissues which are under suspicion. Longitudinal incisions should be made, half again as long as is apparently necessary, in the skin and fascia (outline of treatment given out by the United States Medical Corps). Amputation may be necessary.

The evidence seems to be more favorable in regard to the value of gas bacillus serum, both prophylactically and curatively. Hall[349] has made a careful study of commercial gas gangrene antitoxins and says: "Seven brands

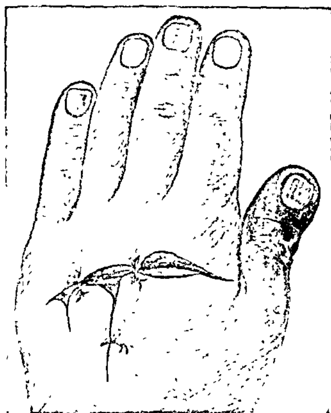


Fig 23.—Gas gangrene of thumb. (Larson, E. E., and Pulford, D. S.: J. A. M. A 94: 612, 1930).

of gas gangrene antitoxin were examined. Six of these were bivalent and were labelled to contain 10,000 units each of Bacillus perfringens and Bacillus septicus antitoxins. One was pentavalent and labelled to contain in addition 3000 units of Bacillus histolyticus antitoxin and 1500 units each of Bacillus novyi and Bacillus sordellii antitoxins. It is pointed out that, owing to discrepancies in the size of the international units for different antitoxins and in spite of the smaller indicated unitage, this serum was heavily overloaded with Bacillus novyi and Bacillus sordellii antitoxins." Hall concludes: "There is no reason to doubt the prophylactic value of seven American gas gangrene antitoxins against the anaerobic infections for which they were intended. One of these serums has been shown to have marked therapeutic values against Bacillus perfringens and Bacillus novyi but only slight therapeutic value

against Bacillus septicus under the conditions of a possibly too severe test."[360]

Penicillin has been recommended in the treatment of gas gangrene.[350] Fisher et al.[351] believe that "the role of penicillin should be to prevent the development of gas gangrene rather than to treat the established infection." They warn against inadequate "prophylactic" administration. MacFarlane[352] reports on 185 cases of gas gangrene in the Sicilian campaign and says that there was no significant difference in the death rate between those who received penicillin systemically and those who did not.[353] Sulfonamides also should be used.

All patients with crushing injuries or contused lacerations which may be liable to develop gas gangrene should be given a routine injection of both perfringens and tetanus antitoxin.[354] Boland[320] advises it in all compound fractures.

Opinion as to the value of x-ray treatment in gas gangrene is controversial. Kelly and Dowell[355] assembled the data on twelve years of roentgen treatment of gas gangrene. The decrease in mortality, they said, indicates that with irradiation the disease need no longer be considered serious. Two of their first eight patients so treated died, but of 364 patients from all sources who were treated during the twelve years ending May 1940 with one or more roentgen treatments, forty-two died, a mortality of 11.5 per cent. The mortality for 288 of the 364 patients given three or more treatments was 5.9 per cent. The diagnosis of the disease in ninety-three cases was based on clinical grounds, in forty-one on clinical grounds and roentgen evidence of gas in the tissues and in 207 on laboratory evidence of Cl. welchii; the method of diagnosis for the remaining 23 was not stated. The number of deaths in these four groups was, respectively, 16, 7, 18 and 1. From an analysis of the data, the authors concluded that roentgen treatment of gas gangrene has a direct effect in preventing and curing the infection and that (1) the administration of serum appears unnecessary, (2) irradiation is effective after serum therapy fails, (3) giving serum may even be harmful to the diabetic patient in whom gas gangrene develops, (4) giving serum may be harmful to aged patients and (5) roentgen therapy of gas gangrene has completely eliminated the necessity of extensive surgical intervention. Amputation and extensive débridement are seldom necessary. They should never be necessary if proper treatment is started early. The study stresses the need for the general use of roentgen therapy for inflammatory disease at the bedside, with an apparatus of adequate kilovoltage. The curative action of x-rays is apparently due to the rays' nonspecific antitoxic effect.[356] Williams and Hartzell[357] in an experience with 34 cases, regard x-ray therapy as almost specific.[358] On the other hand, experimental work on guinea pigs by Caldwell and Cox[359] failed to show more than a slight improvement from x-ray therapy. Erb and Hodes[360] showed that irradiation has "no demonstrable effect on Cl. welchii infection in the pigeon with the dosage of irradiation used."[361]

The occurrence of *gas gangrene in civil practice* has been receiving an increasing amount of attention. Millar[362] collected reports of 607 cases of gas gangrene occurring in civil life with a mortality of 49.7 per cent. The mortality from gas gangrene in World War I in the A.E.F. in France was 48.5 per cent.[363] In 1922 the writer reported a case of gas bacillus infection of the hand following a crushing injury.[364] Callander, Haim and Maximov[365] studied 109 cases of gas gangrene occurring in civil practice. Ochsner and Schmidt[366] reported the case of a gas bacillus infection of the abdominal wall following appendectomy for perforative appendicitis associated with abscess formation. The patient recovered. Butler[367] reported 2 cases of gas bacillus infection of the abdominal wall in a series of 7000 laparotomies. One case occurred after an appendectomy and the other after a colostomy. The 2 patients were treated by multiple incision, and 1 of them survived. Shearer[368] reports a case of gas gangrene of the abdominal wall following gangrenous appendicitis. Death occurred forty-four hours after operation. Quinn et al [369] report four cases of gas gangrene of the abdominal wall and analyze the published reports of cases. Gas bacillus infections have occurred following the hypodermic injections of various medicaments. Heuss[370] reported gas gangrene after the injection of caffeine and digitoxin into a patient with purulent peritonitis. Gas bacilli were subsequently found in the injected solution, but 6 other patients who were given the same injection fluid remained healthy. Anschutz[371]

reported a case of gas gangrene after subcutaneous injections. Wanke[372] was able to collect reports of 25 cases of such infections and stresses the importance of boiling all the needles for five minutes. Lande[373] reported 3 additional cases of gas gangrene following subcutaneous injections. He believes that the gas bacillus germs are present on the skin. Tenopyr[374] reports 24 cases of gas bacillus infection in civil surgery, with a mortality of 29 per cent. Muscles which have been devitalized not only by trauma but also by impaired circulation are a prey to gas bacillus infection. In 1927 Tanner[375] reported 7 cases of gas bacillus infection complicating senile and diabetic gangrene of the lower extremities. In 5 cases the infection developed in an amputation stump. In 1 case of arteriosclerotic gangrene of the great toe and ulcer on the dorsum of the foot, the Bacillus welchii was found in anaerobic culture. Weintrob and Messeloff[376] made a study of 85 cases of gas gangrene at Bellevue Hospital, New York, and found it occurred once in every 7310 cases. In no case was serum used, and the mortality was 45.9 per cent.

Eckhoff[377] describes 23 cases of gas gangrene, 12 following accidents and 11 following ordinary operations. He recommends the plentiful administration of serum, especially when radical removal is impossible in the treatment. Linton[378] has made a study of latent gas bacillus infection complicating gangrene of the lower extremity and reached the following interesting conclusions: "1. Gas bacillus infection may develop in any type of gangrene of the lower extremity resulting in the impaired circulation, regardless of the age of the patient or whether the gangrene is moist or dry or the skin is intact or broken. 2. Conservative treatment, including delay for appearance of a definite line of demarcation, if carried too far in these cases, is dangerous because of possible gas bacillus infection in the gangrenous extremity. 3. Roentgenograms of the affected limb may show gas deep in the muscle planes that cannot be detected by palpation. 4. In any suspected case of gas bacillus infection, immediate amputation is imperative. 5. In such cases, unless there is evidence of good circulation below the knee, it is much safer to amputate through the thigh 6. In cases with a definite gas bacillus infection in the lower leg, either before or after a primary amputation the operation of choice is a guillotine amputation through the lower third of the thigh, with no attempt at closure of the stump." Kraft[379] reports the finding of gas bacilli in 13 wounds in three months without clinical manifestations of their presence. Hendry[380] reports 4 cases of latent gas gangrene infection in soldiers. The acute gas gangrene had its ultimate onset many years after the receipt of the original wound.

Rubenstein et al.[381] report "three cases of a new syndrome characterized by the rapid appearance of subcutaneous gas tumor masses within a few minutes after a superficial laceration of the hand occurred in two plants where an alloy composed of 90 per cent magnesium was being used Each patient had handled this material in a finely powdered form prior to the occurence of injury."

Rabies.—All dog and cat bites should be considered as potentially causing rabies. Even if the animal's tooth does not penetrate the skin, but merely abrades it, it should be regarded with suspicion. Schlotthauer[382] says:

"Rabies is a highly fatal encephalitis or encephalomyelitis caused by a specific infectious organism. It is primarily a disease of canines, especially dogs, but it may affect man and all warm blooded animals. Man may be infected secondarily through the bite of a rabid dog, but rabies can be transmitted by contamination of a wound with infected saliva or tissue. Recently also evidence has been found that the infective agent can pass through unbroken mucosa. . . .

"The morphologic character of the specific etiologic agent of rabies is not known It has some of the characteristics of a virus, but at present the belief is growing that it is a protozoan organism and that the cell inclusion bodies, described by Negri in 1903, are one form of this organism. For convenience I shall refer to the infectious organism as a virus.

"The [illegible] dog, the saliva is consic[illegible] out it has been observed [illegible] of symptoms. Fluid saliva may remain infectious for twenty-four hours or longer, whereas dried saliva usually becomes noninfective after fourteen hours.

"The *incubation period of rabies varies. It is determined by numerous factors, such* as the site of infection, the resistance of the animal and the virulence of the virus. Usually

it is from sixteen to forty days, but cases have been reported as early as fourteen days after infection. The maximal incubation period has not been established definitely. Many investigators have expressed the opinion that the development of rabies many months or even years after exposure is the result of a more recent unobserved infection.

"Since rabies is primarily a disease of the central nervous system, the symptoms manifested are those of severe, rapidly progressive encephalitis or encephalomyelitis. The virus of rabies travels to the spinal cord and brain by way of the peripheral nerves. Therefore, if infection enters through one of the extremities, symptoms of peripheral neuritis and myelitis may be noted several hours before encephalitis, whereas if the infection gains entrance through wounds on the head and neck, symptoms of encephalitis precede those of myelitis. It commonly is thought that rabid dogs become furious or vicious and that they foam at the mouth. Fortunately this is not a frequent or common manifestation of rabies. The period of cerebral irritation usually is very short and unnoticed, but it may persist for three or four days and is then followed by progressive mental depression. Generally, the latter symptom only is noted and the animal is said to have the dumb form of rabies.

"Rabies is always severe, rapidly progressive and fatal. It has not been proved experimentally that any of the lower animals except fowl ever recover from an attack of rabies. Reports of cases in which recovery occurs among lower animals probably are the result of an error in diagnosis. The symptoms of encephalitis from any cause are similar; they differ in magnitude only, and therefore it would be difficult, indeed, positively to diagnose rabies from the symptoms alone.

"Since the virus of rabies travels to the central nervous system through the peripheral nerves, weakness or paralysis of the extremities may be an early symptom when the virus has gained entrance through the spinal nerves. Changes in behavior and mentality are frequently early symptoms. Vicious dogs may become more friendly and quiet friendly dogs may become irritable and hard to manage, but the reverse may also occur. Not infrequently affected dogs whine or bark as if they were being annoyed or worried. They may seek seclusion in some dark corner as if they were trying to hide from the thing that is tormenting them. Rabid animals commonly eat foreign material such as sticks and stones or their bedding. This symptom, however, is also noted in puppies and in dogs which have mental disease due to other causes. Paralysis of the muscles of mastication and deglutition undoubtedly is the most constant symptom noted in animals affected with rabies. This is due to the anatomy and physiology of the nervous system, the route of entry of the virus and its tendency to incite severe destructive lesions in nervous tissue. The nuclei of origin [illegible]
cortex.

"Paralysis of the muscles of mastication and deglutition in animals causes the lower jaw to hang so that the mouth remains partially open and the tongue may protrude. The eyes have a peculiar stare and the voice is changed. At first the paralysis is not complete and the animal can close the mouth or bite, but later this is impossible. The animal then is unable to swallow food or water and the saliva tends to drool from the mouth. The drooling of saliva, however, is not constant for I have observed cases in which the mouth was dry. As the disease progresses into the brain, mentality is impaired and affected dogs may become stuporous or dumb or they may move about and if not confined or restrained have been known to travel for [illegible]
probably never wilfully go out of their way to bite. If they are not entirely unconscious of their actions, they appear frightened and scared of man and other animals. However, this is not true of all animals. Horses and cattle commonly charge at anything that moves, and occasionally they will even charge stationary objects. Since animals affected with rabies early lose their ability to swallow food or water, they rapidly become dehydrated and emaciated. Paralysis and convulsions generally are terminal symptoms. Death usually ensues within three to seven days after the appearance of the first symptoms. Since the course is rapidly fatal and Negri bodies are demonstrated more easily if the disease is advanced, an animal that is suspected of having rabies should not be killed until death is imminent.

"Unfortunately the previously mentioned symptoms may be manifested by encephalitis

or myelitis due to causes other than the specific organism of rabies. Therefore a definite diagnosis of rabies cannot be made from the symptoms alone."

The finding of typical Negri bodies is the most conclusive evidence, but in their absence, subdural or intracerebral injections of suspected material into rabbits, guinea pigs or white mice should be tried.

Cross[383] says: "There is no treatment for rabies in humans. Once the disease develops, it is 100 per cent fatal."

"It appears that the *mortality among untreated cases is fully thirty times greater than among the treated cases.*"[384] If it is known with certainty what dog caused the injury and if it seems certain that this dog is not suffering from rabies, the antirabic treatment may be omitted but the dog must be examined by a competent veterinarian and kept under observation for at least two weeks. Bites of the head and deep bites are the most serious.

Formerly boards of health insisted that all wounds in cases in which rabies was suspected should be thoroughly cauterized with "fuming" nitric acid even as late as three or four days after the patient was bitten. This method is now not approved, and thorough soap and water cleansing is preferred. Shaughnessy and Zichis,[385] after a careful experimental study, say:

"In experiments in which treatment of wounds contaminated with rabies virus was instituted within thirty minutes, only 11 per cent of those treated with fuming nitric acid and only 6 per cent of those treated with soap solution became infected, compared with about 63 per cent of the untreated controls. The application of treatment in two hours was apparently somewhat less effective, and its application in six hours was definitely less effective than when it was applied in thirty minutes.

"In tests using a limited number of guinea pigs, the results of applying tincture of iodine within thirty minutes compared favorably with the results obtained following treatment with either fuming nitric acid or soap solution. However, when tincture of iodine was used after an interval of two hours it appeared to be considerably less effective than the other substances.

"Packing the wounds with sulfanilamide after they had been treated with soap solution seemed to have no effect on the incidence of rabies.

"The results of these experiments show that, in the treatment of guinea pig wounds that have been inoculated with fixed rabies virus, irrigation with 20 per cent solution of soft soap is just as effective as chemical cauterization with fuming nitric acid, and possibly even more effective."

The period of incubation varies from fourteen days to a year or more, usually forty to sixty days. The average period is as follows (Rosenau[386]): man, forty days (apt to be shorter for children or following bites on the face); dogs, twenty-one to forty days; horses, twenty-eight to fifty-six days; cows, twenty-eight to fifty-six days; pigs, fourteen to twenty-one days; goats and sheep, twenty-one to twenty-eight days; birds, fourteen to forty days. I once cared for a patient who had been bitten by a rabid squirrel. Badgers are said to be subject to rabies. Wolf and cat bites are believed to carry a high probability of rabies. It requires fifteen days to produce active immunity to the disease by the Pasteur preventive treatment, and in the cases in which it is indicated the treatment should be instituted immediately.

According to Moore,[387] in the ten years from 1924 to 1933 there were 746 deaths from rabies in the United States. Denison, McAlpine and Gill[388] report that in Alabama from January 1922 to August 1936, 9282 animals

received a positive laboratory diagnosis of rabies. During this time 42 persons died of the disease; 21 of them had received antirabies vaccine and 21 had not. Among the 21 persons receiving vaccine who died, treatment for 20 began within six days after exposure and for 1 after three weeks. Gowen[389] reported that in Illinois in 1936 there were 11 deaths from rabies, and in each of these cases there was one or more violations of the accepted procedures. Blatt, Hoffman and Schneider[390] report 12 cases of rabies at the Cook County Hospital, Chicago, over a period of eight years, all being fatal. At the Pasteur Institute of Southern India, Coonoor, Madras, 28,898 persons received the vaccine treatment for rabies in sixteen years, with a total mortality of 1.11 per cent and a percentage of failures of 0.7.

More important, perhaps, than the first-aid treatment of the wound itself are the complete instructions which should be given to the patient as to the method of inspection of the suspected animal. Whenever possible, the name



Fig. 24.—The cry accompanying the pharyngeal spasm of rabies. (Blatt, M. L.; Hoffman S. J., and Schneider, M.: J. A. M. A. 111: 688, 1938.)

of the owner of the animal should be at once reported to the health officer and police department, who will compel him to keep the dog under observation for a period of two weeks and have him examined by veterinarians. If at the end of this time the dog is free from rabies, infection of the wound may be forgotten. If, however, the dog develops rabies, either as shown by the clinical course of his disease or by the identification of the Negri bodies in the brain of the dead animal, antirabic treatment should at once be instituted. Leach,[391] in a study of 1032 animal brains, found 338 positive, 690 negative and 4 questionable for Negri bodies. Of the 338 positive brains, 3 were negative on mouse inoculation, and of the 690 negative for Negri bodies, 83 showed rabies on mouse inoculation. Of the 4 questionable on microscopic examination, 3 were positive by inoculation. The official bulletin of the Illinois State Department of Health[392] says: "Dogs believed to be rabid should never be killed until a positive diagnosis can be made if a person has been bitten

and there is doubt about the need of treatment. By clinical observation a veterinarian can recognize rabies in an animal. Except in cases of deep wounds inflicted near the central nervous system, a rabid animal will show unmistakable signs of the disease in plenty of time after a person has been bitten to start treatment."

Rosenau says that "persons who apply for treatment of dog bite fall into one of the seven following categories with reference to the Pasteur prophylactic or one of its modifications, such as the Semple method.

"1. The dog is mad: In this case, begin treatment at once.

"2. The dog shows suggestive symptoms: Give the treatment at once. In communities having skilled laboratory facilities wait for diagnosis, provided that this is done promptly.

"3. The dog is not mad: Observe it carefully for ten days, and if no symptoms develop there is no danger of rabies in the person bitten. The treatment is, therefore, unnecessary. (The dog may nevertheless develop rabies after ten days, and if it has been bitten by another dog should be kept in quarantine for six months.)

"4. The dog is not identified: This is a common occurrence, especially with children. Rule in such cases is to advise the prophylactic treatment except in regions known to be free of rabies.

"5. Exposure to saliva: Persons not infrequently apply for advice, giving the following history: They have not been bitten, but they have been licked on the hands and face by a dog that subsequently was discovered to have the disease. Persons are sometimes similarly exposed by washing the mouth of a rabid horse. In these cases the important question is whether there were fissures or abrasions in the skin at the time. There may be little wounds in the skin not evident to the eye. It is possible to infect animals by rubbing the virus on the shaved skin. The rule is, therefore, to advise the protection which the treatment affords to persons thus exposed.

"6. In psychoneurotic patients with a distressing phobia of rabies it may afford comfort to give a mild course of treatment as much for its psychotherapeutical effect as for specific immunity.

"7. Fomites: The question is often asked whether the disease may not be contracted from contact with the virus in saliva upon floors, on playthings and other objects. The situation arises with a rabid dog in the house, where children may be exposed in this indirect manner While theoretically possible, the danger is small; in fact, I have never heard of a case contracted in any such way. The virus is not infective by mouth."

The antirabic treatment is conveniently given by using the commercial preparations of antirabic vaccine, which consist of a fifteen dose series, a dose being given daily for fifteen days. The Illinois Health Department advises that "for wounds about the head and upper body, especially deep lacerations, two treatments daily for seven days and one daily for an additional seven days are recommended. Treatment should start as early as practicable after a wound inflicted by a rabid animal. Park and Williams[393] found the death rate to be 1 to 1000 in over 6000 cases in which treatment was given within five days; but it was 1 to 30 in 313 cases in which treatment was given after three weeks. The closer the wound to the central nervous system, especially the brain, the more imperative is prompt and vigorous treatment." The injections, which are given subcutaneously, are somewhat painful, and it is wise to rotate the sites of injection. The subcutaneous tissues of the abdomen, the upper part of the buttock, the subscapular region, the arms and thighs are the places generally used.

Bassoe and Grinker[394] report in detail a case of rabies vaccine encephalomyelitis. The patient had handled but had not been bitten by a pet dog in which rabies developed and had been given the Pasteur treatment because of a blister from a burn on her finger. Paralysis set in after the thirteenth injection, and she died on the forty-first day after the commencement of the injec-

tions. Bassoe quotes Remlinger as saying that among 1,164,264 persons treated for rabies all over the world, there were 529 cases of paralysis.

Fetherston and Cooper[395] believe that it is good treatment to dissect out the scars of the bite if the patient is seen long afterward. Immunization of dogs against rabies by vaccination is being studied with increasing interest. It probably has considerable value.

Human Bites.—Bates[396] has made a careful study of over 200 cases of wounds infected by human teeth. In contrast to human bites, dog bites, in the absence of rabies, are not considered to be very serious from the standpoint of infection. Bates says the human "mouth contains more dangerous organisms than any other part of the body. A wound caused by a tooth is infected immediately with many organisms of varying degrees of virulence. In addition, the infection is planted on the fertile soil of crushed tissue." Ronchese[397] defines as a "dental injury" the callus resulting from pressure against the teeth due to finger-sucking in childhood. Fuller and Cottrell[398]

Fig. 25.—Human bite infection before amputation. (Fuller, C. R., and Cottrell, J. C.: J. A. M. A. 92: 2017, 1929.)

report the case of a severe infection of the finger following a bite by a person suffering from ulcerative stomatities due to Vincent's angina. Despite intensive chemical and surgical treatment, amputation was necessary (Fig. 25). A number of other organisms have been recovered from these wounds. Actinomycosis of the subcutaneous tissue of the forearm secondary to a human bite has been reported by Robinson.[399] The avulsive and amputating bites are less severe than the penetrating bites (Bates).

Flick[400] reports a case of human bite of the thumb which was followed by a gangrenous infection of the hand and forearm which terminated fatally on the sixteenth day.

In regard to human bites of the hand Miller and Winfield[401] say:

"The [illegible] ... [illegible] was utilized."

Mason and Koch[402] made a careful analysis of 13 cases of human bite infections together with a study of the routes of extension of infection from the dorsum of the hand. These authors point out that, save for furuncles and carbuncles, there are no infections which involve the dorsum of the hand and proximal phalanges more frequently than human bite infections. The infection is not due to any one type of organism but to a mixed infection. Mason and Koch summarize their study as follows:

"Bite infections are frequently prolonged in their course and difficult to clear up because the infection is usually introduced deeply into the tissues through a comparatively small wound, because of the character of the infection, because of the anatomical arrangement of the structures involved, and because of the relatively low resistance of fascia, tendon, and bone to a mixed infection such as is caused by the organisms present in the mouth.

"Such infections when introduced into the tissues of the dorsum of the hand—the most common site of inoculation—tend to spread to definite areas, and this extension depends particularly upon the exact site and depth of the primary inoculation and upon the ease or difficulty with which the infectious material can escape to the surface.

"In the treatment of such infections an exact knowledge of the sites to which infection tends to spread is of importance. These are in order of frequency, the subcutaneous space of the dorsum of the hand, the subfascial space of the dorsum of the proximal phalanx, the subaponeurotic spaces of the hand and fingers which lie directly over metacarpal bones and proximal phalanges, the metacarpophalangeal joint, the fascial spaces of the palm and the flexor tendon sheath. If these sites are kept in mind, extension of infection can be recognized early and accumulations of pus drained before extensive necrosis of tissue has taken place.

"Unless such infections are drained early and adequately, bone, joint, and tendon involvement are certain to occur and to lead to extensive impairment of function."

Miller and Winfield[403] treated 61 patients with human bite injuries within four hours after the injuries were inflicted. Cases in which swelling and evidence of infectious extension were already present were not included in this series even if within the four-hour period. The treatment was soap and water cleansing and irrigations, limited débridement and continuous wet dressings of saline, boric acid or magnesium sulfate solution. The results were "most gratifying." Boyce[404] reported on 90 human bite injuries. Important points from his paper are as follows: To close a human bite is the worst possible treatment. The treatment in early cases is the conversion of the anaerobic state to an aerobic state and the excision of devitalized tissue in which the fusiform bacillus and spirochete [illegible]

[illegible] particularly if cellulitis and lymphangitis are present. The wound should be widely opened [illegible]

[illegible] immobilized. Constitutional treatment is carried out as necessary. Infections due to bites [illegible]

[illegible] finger and twenty-one by complete amputation of a finger; in four also a partial removal of a metacarpal bone and in one amputation of the arm was necessary. The period of *hospitalization* was one or two days in twenty-four cases, eighty-seven days in one case and between one week and seven weeks in the others. One patient died of pneumonia on the sixty-seventh day of hospitalization and the eighty-eighth day after injury.

Cohn[405] admits the patient with a human bite to the hospital. He says:

"Under general anesthesia and a tourniquet on the arm we excise the local wound. If examination of the extensor tendon and joint capsule shows them to be intact, the wound is packed lightly, and the hand and arm are splinted and the patient kept in the ward. If, after forty-eight hours, no infection becomes apparent, he is discharged to a follow-up clinic.

"If the tendon and joint capsule have been injured, the area should be excised and the joint capsule widely opened. Welch favors cutting the lateral ligaments and the web spaces on either side as well. It is necessary to cut the extensor tendon as it will fall back and obstruct drainage of the joint. Boric and vaseline gauzes should not be used as packs as they favor anaerobiasis.

"If the patient is seen when infection is already established, that is, more than twenty-four hours after injury, we believe that the treatment should be conservative. The hand should be splinted and warm wet poultices applied. The lymphangitis and cellulitis will recede. If an abscess localizes, it should be drained. These localized abscesses may possibly be due to inoculation of the intermetacarpophalangeal bursae which lie at the metacarpal heads dorsal to the transverse capitular ligaments, between the second and fifth fingers.[406]

"If the joint is involved on entry, the heads of the metacarpals soon become involved. Characteristic *x*-ray evidence of osteomyelitis appears and the wound continues to discharge pus. Even if the finger is saved, it will be stiff and of questionable value.

"Occasionally the infection may rupture anteriorly and a tendon sheath infection result as in Welch's Case 9. If the bite has been over a terminal joint, the tendon sheath may be inoculated directly as in Case 20 of the series reported here. By way of the lumbrical canals the thenar or midpalmar spaces may be involved.

"When the metacarpophalangeal joint is involved and there is osteomyelitis of the metacarpal head, amputation should be done through the metacarpal head. The cartilage should always be removed.

"Postoperatively, the splinting should be continued. The dorsum should be directed downwards to promote drainage by gravity. Sterile hand soaks can be used with benefit. This should not be continued for more than a few days because of the resulting maceration and edema. The solution used is not considered of much importance. Saline solution or potassium permanganate 1/1000 is satisfactory. Dakin's solution is somewhat painful, especially in the acute stages."[407]

Certainly zinc peroxide would seem to be indicated in the treatment of human bites. It is important that an active preparation of zinc peroxide be used and that it be meticulously applied to all recesses of the wound after appropriate surgical débridement.

Lowry[408] reported 122 cases of human bites treated at the Beekman Street Hospital in New York. Of the 64 cases traced, there were poor results in only 2. Lowry advises the following treatment: 1. All human bites are thoroughly wiped out with fuming nitric acid applied with a cotton wound applicator of a size appropriate to the wound, and the cotton is saturated but not dripping. If any acid is spilled on the skin the area must be immediately washed with cold water. 2. Wet dressings are applied in all cases and instructions given for hot soaks at home. 3. All patients with human bites are referred to the out-patient department to be seen the next day. 4. No tetanus antitoxin is given. 5. No wounds of this type are sutured. Cauterization with nitric acid may seem brutal, but it is necessary to observe only one of these creeping infections start up the arm to realize that heroic measures are fully justified if they will prevent such an outcome. Maier[409] calls attention to the frequency of joint and tendon injuries in [illegible]
w[illegible]
H[illegible]
Welch,[410] on the basis of a study of 18 cases at the Massachusetts General Hospital, advocates diathermy excision of the laceration when the patient is seen early. McMaster[411] advocates wide excision of penetrating human [illegible]
[illegible]
in [illegible]
ha [illegible]
oc[illegible] only once (a case in which the extensor tendon of the index finger was severed,

with fracture of the distal end of the second metacarpal extending into the joint). The technic of Bates is as follows:

"The patient is given a gas-anesthesia as soon as permission can be obtained. A cautery knife, or a postcautery blade, is heated to a cherry red. In the penetrating bite cases, the whole tooth mark is removed with the cautery. There is practically no bleeding and the nerve ends are destroyed by the heat. This wound is dressed with a mild antiseptic. The patient wakes with a pain-free wound. Subsequent dressings consist of boric acid ointment, or mercurochrome or other mild antiseptic applications. The scar produced is much less than one resulting from a scalpel excision of the same size. In the avulsive and amputating bites, the entire raw surface is seared with the cautery. . . . The best time to apply this treatment is immediately after the wound is produced."

Healing is generally complete by the fourteenth to the twentieth day.

Snake Bites.—Pope and Perkins[412] have made a study of the differences in the patterns of bites of venomous and of harmless snakes. They say: "If a venomous snake leaves but two marks, there can be no doubt about its identity and just where the first-aid cuts should be made; if many marks are left by either a poisonous or a harmless snake, the victim, already suffering

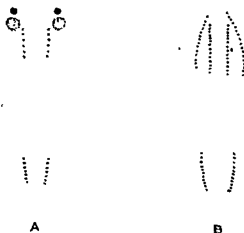


Fig. 26—Diagrams of almost perfect bite patterns of a poisonous and a harmless snake. The stippled areas are approximately over the pockets of injected venom. *A*, western diamond-back rattlesnake. *B*, bull snake. (Pope, C. H., and Perkins, R. M.: Arch. Surg. 49:331, 1944.)

from tremendous nervous strain, may be called on to exert considerable judgment in determining the nature of the bite and then, in case it is dangerous, finding the fang punctures.

"In the United States, all poisonous snakes except two kinds of coral snakes are pit vipers. Since coral snakes never strike but inject their venom by seizing a victim at close range and chewing, they have been left out of consideration; obviously the pattern of their bite is a separate problem. The pit viper of the United States that inflicts the greatest number of serious bites is the western diamond-back rattlesnake (Crotalus atrox); hence this species was chiefly used in the demonstrations. Conclusions based on it are no doubt valid for other rattlesnakes in the United States. The pit vipers of the United States lacking the rattle are the water moccasin (Agkistrodon piscivorous) and the copperhead (Agkistrodon mokasen), and a representative of each of these was also used to complete the list of domestic pit vipers. Since Klauber has suggested that some tropical American kinds bite in a somewhat different manner, it may be best to refrain from generalizing about pit vipers other than those of the United States.

"All of the harmless snakes in the United States big enough to bite have four rows of teeth in the upper jaw and two in the lower. . . . Since the teeth in any one of the harmless snakes are usually similar in size, structure and shape, most of them come into play during the act of biting and in a perfect bite leave six rows of punctures, four rows in one group and two in the other (Fig. 26B). In the pit vipers, the outer row on each side of the upper jaw has been reduced to a single large, erectile, hollow tooth, the fang. The bite of a pit viper, therefore, should leave not more than four rows of punctures in addition to the two large perforations made by the fangs (Fig. 26A).

"If, in defending itself, a pit viper stabs rather than bites, only the fangs can come into play; if it actually bites, the two rows of small teeth of the upper jaw and the two of the lower will make their marks in addition to the fangs, which are much farther apart than the rows of teeth. Due allowance must of course be made for bites on finger and toe tips and for those that for various other reasons do not make discernible patterns. Interference by clothing may prevent punctures by the teeth, but it is well known that bites through clothing are not nearly so dangerous as those encountering no such obstruction."

The cobra is the deadly snake of India, and in that country from 1887 to 1911 the average annual human death rate from poisonous snakes was 21,000. Doughty[413] says that the hazard of rattlesnake bite in the United States is increasing because of the increase in outdoor recreation.* Prevention of rattlesnake bites is possible to a great extent by the wearing of leather puttees. Doughty concludes that there is a specific antivenom and that, while local treatment is inefficient, ligation is a valuable first-aid treatment. In the discussion of Doughty's paper it was stated that the mortality in 67 cases reported in Texas in which antivenom was not used was 34.3 per cent, and in 83 cases treated with antivenom, it was 6 per cent. Fairley[414] says that in sheep, excision of the bitten area proved an effective therapeutic measure only when a ligature was applied immediately after the bite, that is, within one minute. In general, it is probably best immediately to apply a tourniquet above the wound, surgically to enlarge the wound, to do a local venesection, to suck out the wound (if there are no abrasions in the mouth) and to pack it with glycerin gauze. Appropriate antivenin should be given as soon as possible. As most antivenins are prepared from horse serum the patient should be tested for sensitivity, and desensitization should be attempted if necessary. If there is no improvement three to five hours after antivenin is employed, an additional amount should be given. Da Costa says that the elder Gross "was accustomed to relate in his lectures how he had seen an army officer blow off his finger by a pistol the moment after it was bitten by a rattlesnake, and thus escape poisoning."[415] Allen[416] contends that timid excision is practically useless. He says that when the condition is dangerous, reasonably early excision of a mass of tissue, such as is commonly removed in a carbuncle operation, is helpful. In a sufficiently desperate emergency, excision can be performed by an unskilled person. Amputation is occasionally to be considered.

On the basis of experiments evaluating the local treatment of venomous bites, Allen[417] states that an occlusive tourniquet can be employed successfully for the treatment of poison-

* Eli Lilly & Company have published a valuable series of maps showing the distribution of poisonous snakes in the United States.

ing with strychnine and presumably other substances which are rapidly absorbed and disposed of, but that it is wholly harmful in the management of snake bite and its use should be abandoned. Because of local diffusion and binding of venom, the earliest possible excision of a large area of tissue, somewhat as in a radical carbuncle operation, offers hope of benefit. In still more desperate cases, amputation is a more positive remedy. Local refrigeration is of no practical value, unless sometimes as an anesthetic. It multiplies the time during which circulation and absorption can be arrested and inhibits the local destructive action of venom, which is the chief disadvantage of the tourniquet method. Failure to save life under these conditions condemns the tourniquet theory. However, the tourniquet may sometimes be serviceable with or without refrigeration as preliminary to a delayed amputation. Since serum treatment is unavailable or delayed in the majority of snake bite cases, it is important that the effectiveness of mechanical methods such as the Jackson plan and the foregoing procedures be more adequately studied and taught. With the proper use of such methods, it seems possible that the mortality from all kinds of venomous bites may be almost abolished.

At the Robert B. Green Hospital in San Antonio, Texas, many patients with rattlesnake bites are treated, with a mortality of less than 2 per cent. The treatment was developed by Dr. Dudley Jackson and is essentially as follows: The absorption of the venomized lymph is retarded by the application of an elastic tourniquet, which is not tight enough to stop the blood circulation. Incisions ¼ inch deep, in the form of a cross, are then made all over the swollen area, and suction bulbs are applied for about twenty minutes in every hour as long as there is any lymph to remove. During the intervals between suction periods, packs soaked in Epsom salts are applied to the bitten limb.*

Diphtheria.—Occasionally the Klebs-Löffler bacillus may be found in wounds and identified by smear or culture. Löhr[419] says that wound diphtheria is seen only in the winter and varies with the frequency and gravity of pharyngeal diphtheria. In 154 children on his service (December 1935 to May 1936) he encountered 7 instances of wound diphtheria and 14 of the pharyngeal type. According to Löhr, the lesions most subject to diphtheria are those with torpid course in poorly nourished tissues, such as bone fistulas, chronic osteomyelitis, pleural fistulas, cancer and ulcers, particularly ulcers from *x*-rays.

Local signs vary; in addition to the typical examples, with a characteristic false membrane, other patients may show nothing, and only bacteriologic examination reveals the bacillus. The "phlegmonous" type is serious, is seen only in young children and is accompanied by erysipelatoid infiltration of the skin. A certain number are followed by paralysis and death; Löhr saw 3 deaths from cardiac failure (1 adult and 2 children), occurring when the aspect of the wound changed suddenly and was covered by the grayish-green membrane. The condition is resistant to therapy; locally, antiseptics and antitoxin have no effect, and even serotherapy may have little action on the wound infection. Löhr believes prophylaxis is best—a search for and isolation of carriers and vaccination of those who are susceptible, *e. g.*, children with chronic osteomyelitis necessitating long hospitalization.

Scarlet Fever may occur in wounds (traumatic scarlatina). The eruption takes place at the wound and from there spreads over the body. Scarlet fever of this type has a less severe course than ordinary scarlet fever.

Erysipelas is a cutaneous infection caused by the hemolytic streptococcus

* An excellent report on the poisonous snakes of the United States is given in a Department of Agriculture bulletin.[418]

and invariably originates in a wound. The wound may be so minute, however, as not to be visible. Erysipelas originating from lacerated wounds occurs much less frequently than formerly owing to improvements in first-aid treatment and proper technic in dressing. It generally occurs on the face and is ushered in by chill and fever; while most commonly running its course in from four to eight days, it may last for weeks. The mortality in hospitals, according to Tileston, is from 4 to 9 per cent. The sulfonamides are now recognized as the most important single agent in the treatment of erysipelas.

Toomey[420] found that of 76 patients with erysipelas at the Cleveland City Hospital who were treated with sulfanilamide, 72 recovered. Shank and his associates[421] report on 165 consecutive cases of erysipelas at the St. Louis Isolation Hospital treated with sulfonamides with a mortality of 3 per cent. Four of the five fatalities were in patients over sixty years old with chronic heart and kidney disease. The authors believe that the sulfonamides have made other treatments of erysipelas obsolete. Siegel and his associates[422] report 303 cases of erysipelas at the Los Angeles County Hospital treated with sulfanilamide. The gross mortality for the series was only 1.3 per cent. The dose of sulfanilamide for patients up to 5 years of age was 0.065 Gm. per pound of body weight for twenty-four hours. Half of the total dose was given at once and the other half was given in divided doses every four hours over the remaining twenty-four hours. After twenty-four hours the initial dose was reduced by one third and on the third day to one-half. This maintenance dose was given for three to five days after clinical cure ensued to prevent relapse. Older children and adults were given similar treatment except that the dose was calculated at 1 Gm. for 20 pounds (9 Kg.) of body weight for twenty-four hours. The average sulfanilamide level in the blood of 121 patients determined forty-eight or more hours after admission was 5.8 mg. per hundred cubic centimeters. (See section on Sulfonamides.)

Copious administration of fluid is desirable. Reports on the use of penicillin are not at hand, but it would seem to be indicated. Streptococcus antitoxin[423] and ultraviolet light have been considered helpful.[424]

Miscellaneous Bites and Stings.—*Black Widow Spider.*—The black widow spider, Latrodectus mactans, is a shiny, coal-black spider, usually brilliantly marked with red or yellow or both. The female, which is always the one responsible for the bites, is often ½ inch in length and may stretch its slim, glossy black legs over as much as 2 inches. The markings vary somewhat, the most constant being a bright red patch, shaped like an hourglass, on the ventral surface of the abdomen. Its unesthetic, coarse, straggly, three dimensional web aids in the recognition of this spider.

Bogen[425] has given valuable information in regard to bites by this spider. He says that the black widow spider is found in more than half of the United States and that 380 instances of systemic poisoning from its bite have been reported. Unnecessary operations on such patients could be avoided if all physicians recognized that an acute condition with rigidity of the abdomen, fever and leukocytosis, and occasionally nausea and vomiting, may supervene as a result of the bite of a black widow spider. It may be differentiated, however, from acute abdominal lesions requiring surgical intervention by the presence of spasm in muscles other than those of the abdomen, by the absence of marked local abdominal tenderness and by the concomitant rise in the pressure of the blood and spinal fluid.

Kirby-Smith[426] studied 24 cases of black widow spider bites. Eleven of the bites were on the penis, four on the buttocks, one on the scrotum, one on the thigh, four on the arms and hands, one on the chest, and one on the knee, and the site of one was not mentioned. Sixteen of the victims were bitten while in privies. Twenty-two of the patients were males. Symptoms ensued from five minutes to two and a half hours after the bite. The bites were inflicted from April to October. There was one death, and in one case a mistaken diagnosis led to celiotomy. Death following a bite by a black widow spider is uncommon, according to Kirby-Smith, who says that arachnidism results in complete recovery without sequelae in three days or less.[427] Frank[428] describes a burning, stinging sensation in the soles of the feet for twenty-four hours after spider bites in 12 cases among soldiers.

The mortality rate is low, and patients usually recover spontaneously within a few days, but the suffering is intense. Seventeen fatal cases have been reported. The prevention of arachnidism depends on popular education as to the danger of these spiders and the advisability of their eradication. Local treatment of the bite should consist of simple antiseptic applications; additional trauma by incision, cauterization or the injection of hypothetic antidotes should be avoided. Stimulation and alcoholic drinks are usually contraindicated. Harmful surgical treatment may be obviated by a correct diagnosis. Opiates and hypnotic drugs may be used as palliative measures, together with sedative hydrotherapy and the reduction of intracranial pressure by the administration of hypertonic solutions or by spinal puncture. Specific treatment with serum from convalescent victims is of value, particularly if given early.

Noon and Minear[429] used specific antivenin (Latrodectus mactans) for the treatment of six cases of arachnidism. Their series is small for the drawing of definite conclusions, but certain points are obvious. The greatly reduced morbidity of patients treated with antivenin is notable when compared with the morbidity for those receiving nonspecific treatment. In one of their patients receiving both nonspecific and specific treatment, they felt that the tremendous reduction of the morbidity was due to the antivenin. It has been their experience that when antivenin is given before symptoms are severe and definitely established, the morbidity is practically nil. When the symptoms are severe and several hours have elapsed before antivenin therapy is instituted, the final curative effect is delayed in proportion to the time of the spider bite and the severity of the symptoms at the time of treatment. It seems possible that more prompt relief would result by giving twice the usual dose of antivenin in the severe cases when much time has elapsed after the bite and the institution of treatment. In two of the author's patients treated with antivenin a delayed serum reaction (hives) developed. Their duration was forty-eight hours.

Gilbert and Stewart[430] advise the intravenous injection of 10 cc. of 10 per cent calcium gluconate with rapid relief of pain. The intramuscular route may be used in children.

De Asis[431] recommends the intravenous injection of 25 per cent solution of magnesium sulfate for this bite. Intravenous injection of 10 cc. of 10 per cent solution of calcium gluconate may relieve the pain. Mason[432] comments on the relief of the severe pain following the slow intravenous injection of 10 cc. of solution of calcium chloride. Excellent results were obtained by Bell[433] by the injection of neostigmine and atropine. Allen[434] believes that block excision with a sharp knife is of value in some cases.

Bee Stings.—In regard to bee stings the American Medical Association[435] makes the following statements:

"The literature contains a number of references dealing with the marked toxic effects of the sting of bees. In discussing the general question it is important to realize that any of three possible reactions may take place. The first is the toxic effect of the venom contained in the stinger. This material is toxic to man and affects every one if the dose is adequate. Some individuals may respond to a very small dose. The symptoms described consist mainly of circulatory collapse, coma and hemolytic changes in the blood stream. It is not to be regarded as an anaphylactic or allergic reaction.

"Another type of reaction as the result of the sting of bees is allergic. This may consist of any of the symptoms commonly seen in ordinary clinical manifestations of allergy. Generalized urticaria and angioneurotic edema have been most frequently described. Asthma or hay fever has also been described as an effect of bee sting. Two possible explanations for the allergic reaction have been advanced. One is that the individual is pollen sensitive and the bee sting has introduced pollen (Gibb).[436] From the more recent observations by Benson and others it seems unlikely that this is an important cause of allergic reaction.

"The most exhaustive piece of work on allergy from bee sting (Benson, R. L., and Semenov, H.: Allergy in Its Relation to Bee Sting[437]) appears to indicate that the symptoms produced are due neither to the toxic fraction of the poison nor to the pollen, but rather to the protein of the bee. These authors found that, after removal of the poison from the stinger mechanism, extracts of the stinger and of the body of the bee were capable of producing allergic responses in a sensitive individual.

"Attempts at desensitization are worthy of trial (Braun, L. I.: Desensitization of a Patient Hypersensitive to Bee Sting,[438] and also Benson and Semenov). The last mentioned authors extracted the venom-free stingers and the body of the bee separately and gave injections with gradually increasing doses with an apparently almost complete clinical desensitization. For details the reader is advised to consult Benson's original article. For prevention of reactions other than specific desensitization it is possible that the administration of ephedrine about one-half hour preceding exposure might be of partial benefit. For the treatment of the reactions, epinephrine hypodermically should be the most efficacious remedy. For more prolonged effect after epinephrine has been administered, ephedrine orally should be used."

The intravenous injection of 0.05 to 0.20 cc. of 1:1000 solution of epinephrine has been recommended for bee stings.[439] The stinger should be lifted out with a knife, not pulled out.[440]

Jex-Blake[441] states that little or nothing seems to be known about the nature of the venom of wasps, bumble bees and hornets. In human beings the reaction to bee and wasp stings varies with their idiosyncrasy: The hardened bee keeper may be stung by twenty bees and have nothing to show for it but a few small, painless and transient pimples, while another person may be stung only once and die in a minute or two if he chances to be hypersensitive to the venom. Hypersensitivity in human beings may take two forms: allergy and anaphylaxis. In the postmortem examination of persons killed by bee stings the following was found: (1) voluminous, overfilled, downy and emphysematous lungs, possibly exuding frothy fluid, (2) overdistention of the right side of the heart and (3) splanchnic

more painful. In another paper Jex-Blake[442] reports the case of a healthy man of 45 who was stung four or five times while driving a swarm of bees out of his veranda. These stings gave rise to the usual transient painful swellings. A fortnight later he was again stung on the face four or five times; in about two minutes he collapsed and died. Artificial respiration, continued for an hour, was without effect. It seems reasonable that this patient was sensitized or rendered hypersensitive to bee venom by the first four or five stings. Helm[443] reports a bee sting in a twenty-two year old soldier who became unconscious in five minutes. Respiration was rapid, and the lungs filled with coarse rales. The blood pressure was unobtainable; the pulse rate was 128. Fifteen minutes after the sting, 0.5 cc. of adrenalin was given intravenously, and 0.5 cc. more was given subcutaneously fifteen minutes later. An oxygen tent, external heat and intravenous 10 per cent dextrose in saline solution were used. The patient soon recovered consciousness, and ninety minutes later the systolic pressure was 100. Intravenous injection of calcium gluconate has been highly recommended for the relief of bee stings and wasp stings.

Scorpion Stings.—In answer to a query in regard to scorpion stings, the American Medical Association says that scorpions occur practically all over the world and are especially common in the tropics. Many deaths, especially of children, have occurred following the

should not be used, as a portion of the head of the tick may break off and remain in the skin. Oil on the skin may aid in inducing the tick to loosen his hold. The wound should be cleansed with soap and water. With regard to prophylaxis, trousers should be worn tucked into boots. Carbon tetrachloride or carbon disulfide will kill ticks in clothing in a few hours in a closed space.[447] Paralysis may be caused by other ticks than the wood tick.[448]

Rat Bite.—Aside from the wounds themselves, rat bites are of interest in that they occasionally are the source of rat-bite fever. This disease is rare in the United States The causative organism, Spirochaetae morsus muris,

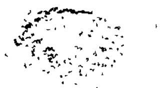


Fig. 28.—Wood tick with beak buried in skin (Wiener, K : J. A. M A. 113.)

is destroyed by arsenical drugs. The diagnosis is made positive by finding the causative organism in smears of the venous blood of the patient or in the cardiac blood of a mouse into which 2 cc. of the patient's blood has been injected fourteen to twenty days previously. According to Rogliano:[449]

"The clinical course is characterized by development of an inflammatory lesion at the site of injury followed by the onset of fever with recurrent paroxysms of chills and fever, muscular aches and pains, cutaneous eruption, lymphadenitis and lymphangitis, neutrophilic leucocytosis, and varying degrees of prostration, and responds promptly to the administration of arsphenamine (and similar drugs) intravenously "[450]

Desensitization to Insect Bites.—For information on desensitization to flea bites, reference should be made to an article by Hatoff.[451]

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CHAPTER III

INFECTIONS OF THE SKIN AND SUBJACENT TISSUES

FURUNCLES AND CARBUNCLES

According to Ayres, Anderson and Foster,[1] "The etiology and histology of the furuncle and carbuncle are so elementary that the barest outline will suffice to bring out the salient points. The furuncle is an external infection by a staphylococcus that has gained entrance to a hair follicle. An inflammatory reaction is set up along the whole length of the hair follicle. A densely packed zone of leukocytes appears at the center of the process. About these a walling off zone of fibroblasts appears, beyond this a loosely packed zone of leukocytes and fibroblasts and beyond this a zone of hyperemia. Usually the central portion of this concentric pattern undergoes necrosis and pus appears. Under ordinary conditions the pus makes its way to the surface along the hair follicle following the line of least resistance and appears at the surface of the skin as the yellow 'head' of the boil. Sometimes, however, if the infection is especially virulent or the resistance of the patient is low, the infection extends deeply into the subcutaneous tissue along the columnae adiposae, spreading laterally along the panniculi adiposi and rising toward the surface along adjacent hair follicles, thus producing a large inflammatory area with multiple heads or a carbuncle. A carbuncle may range in size from that of a silver quarter (24 mm.) up to that of an adult hand or larger. Diabetes predisposes to large and extensive lesions."

Price[2] says: "Certain characteristics of furunculosis point definitely to a local cause for the disease rather than to any systemic abnormality. Furunculosis usually starts with a single infection; thereafter boils tend to appear in succession and not simultaneously in a single crop, as might be expected in a blood borne infection. Furthermore, the individual furuncles invariably begin in hair follicles or their associated sebaceous glands. The lesions [illegible] individual are identical. Not infrequently furunculosis occurs in previously healthy persons in whom no systemic abnormality can be demonstrated. Even during the height of furun- [illegible] disease as well. Constitutional defects associated with furunculosis are thought to be contributory, secondary or coincidental."

The furuncle is the site of a conflict between the invading staphylococcus and the natural defensive forces of the body. There is no fundamental difference between a boil and a carbuncle. The difference is due solely to anatomic and mechanical factors. A carbuncle differs because of the tough skin connected to the underlying fascia by strong vertical septums.[3] The infecting organism comes from without and passes through a portal of entry in the skin, generally a hair follicle, and the reaction to its invasion depends upon the virulence of the particular strain of bacteria, the state of the defensive forces of the host and the anatomic peculiarities of the site invaded.

There are all gradations between pimples and malignant carbuncles. The reaction of the tissues to the staphylococcus is cellulitis, suppuration or necrosis. The "core" or slough is composed of dead tissue and dead cells. Severe pain is not a marked symptom of many very serious carbuncles of the neck. The situation of the furuncle is an important factor in its serious-

Schroeder[8] has made some interesting observations on the injection of penicillin in procaine in cases of localized furuncles, other than those in the "danger zone" of the face. He injects into the furuncle and the surrounding tissue 2 cc. of penicillin (10,000 units) and 0.5 cc. of 1 per cent procaine, using a no. 25 ¾ inch needle. The injections are given at twelve hour intervals, and the furuncle is covered with a firm, dry dressing. No hot fomentations or local heat is used. Only 2 of the 100 boils he has treated recently were incised, and three injections were required by 3 boils. The results were as follows:

	No.	%
"Moderate Boils: Total of 76		
A. Relief of pain:		
1. After first injection.	18	24
2. After second injection.	53	69
B Course:		
1. Resolution.	25	33
2. Arrest.	42	55
3. Suppuration.	9	12
4. Unaffected.	0	0
"Severe" Boils: Total of 24		
A. Relief of pain:		
1. After first injection.	3	13
2. After second injection	17	70
3. No relief.	4	17
B. Course:		
1. Resolution.	0	0
2. Arrest.	7	29
3. Suppuration.	12	50
4. Unaffected	5	21

Schroeder feels that local injection of penicillin is of no value if the infection has passed the local defense barriers. Otten[9] reports excellent results from use of 1 cc. of penicillin solution (20,000 units) together with 1 cc. of 2 per cent procaine hydrochloride. Similar good results have been reported by Rose and Hurwitz.[10]

In this connection it is not amiss to remember the advice of Meleney:[11] "In a case of septicemia due to pyogenic or necrotizing organisms it is the surgeon's responsibility to locate the distributing focus and, if it is possible, to remove, drain, or isolate it." Meleney says further, "If boils or carbuncles are to be incised or excised, it should be done adequately with the incision extending beyond the area of induration, and with the minimum of trauma." The situation of the lesion is, of course, of importance. In carbuncles Livingston[12] advises immediate excision of the necrotic tissue by a double crucial incision. He undercuts the lateral flaps in such a manner that they may be approximated with adhesive plaster, as granulation progresses, to bridge over the skin defect. With all incisions the undercutting of the skin flaps is important in order that all the diseased fat columns may be opened (Fig. 29). Loose gauze packing for a couple of days is desirable in order to divulse the flaps. Currie[13] has treated 39 carbuncles by means of parallel incisions with good results. Each incision extends down to the fascia. They extend outward into the healthy tissue and are from 2 to 4 cm. apart. Each bridge of tissue is separated from its bed, and the resulting cavity is packed thoroughly with

gauze. Wet compresses are applied for several days. The separation of sloughs and the outflow of pus commence within two days, and then healing proceeds quickly. The cosmetic result is better than in the case of crucial incision. Urban Maes[14] says that he has long abandoned the "usual methods of crucial incision and radical excision because of the long period of disability which follows their use, as well as the great sacrifice of tissue inevitable with them." He has substituted for them the "gridiron incision (Fig. 29), which is entirely satisfactory in lessening the tension and providing an outlet for the infection, while at the same time healing is more rapid and the hospital stay is mark-

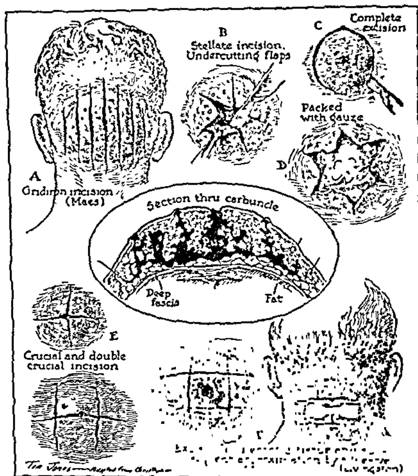


Fig. 29.—Types of incisions for carbuncles. (By permission of Johnson & Johnson.) The author considers it to be important when the gridiron incision of Maes is used in the neck that the parallel incisions be *transverse* rather than longitudinal.

edly decreased." After Maes has made his incision, which extends well beyond the area of inflammatory reaction, there may be rather free hemorrhage, which is easily controlled with gauze soaked in 1 per cent carbolic solution. "No drainage is employed and no packs are used, so subsequent dressings are as painless [illegible]

[illegible] and act as grafts, and healing is surprisingly rapid." The author employs the parallel incisions of Maes but believes it to be important that the incisions be made *transversely*, that is, in or parallel to the skin creases of the neck. By this method the resulting scars will be less unsightly. A dress-

ing of sulfonamide or penicillin carbowax (see Index) is very effective.[15] Dakinization of the wound with secondary suture is employed by some surgeons.[14] As the sloughs become separated they are lifted out of the wound, or their redundant parts are cut off. They should not be forcibly pulled out, as not only is it painful and unnecessary, but it is liable to cause bleeding and to open new channels of infection.

As is well known, the chief danger in furuncles of the face is cavernous sinus thrombosis and infection by way of the facial vein (Hinton[16]). Traumatism is believed to increase the risk of thrombophlebitis with the meningeal sequelae. There is great danger in picking and squeezing. Even the use of a sharp knife may aggravate the condition. If a patient with a facial carbuncle exhibits progressing edema, spreading infiltration, thrombophlebitis, fever, fast pulse, severe pain, chills and a positive blood culture (*i. e.*, the malignant type), Schmid[17] recommends wide total excision with the diathermy knife. (See section on Infections of the Head.)

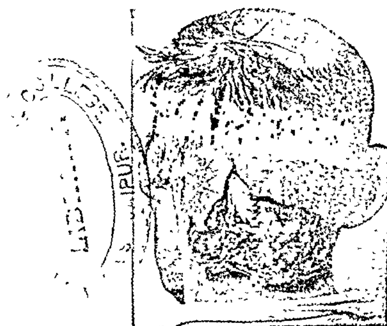


Fig. 30.—Radical excision of a carbuncle of the neck.

Placing the site of the carbuncle or furuncle at *rest* is believed to be of first importance. Sir David Wilkie[18] says: "Incision into a boil on the supposition that it is a form of abscess is wrong in theory and mischievous in practice. *Complete immobilization by strapping with elastoplast is, in my experience,* the most effective form of treatment." Ovens[19] applies adhesive strapping, such as elastoplast, directly over the carbuncle and the surrounding skin for 4 to 5 inches beyond the indurated area. This plaster is removed when it becomes soaked with discharge, and a new one is applied. Putting the patient to bed is often a wise procedure.

Innumerable *salves* have been devised as applications for furuncles. These cataplasmas, or poultices, have been designed to relieve pain, to exert a bactericidal effect, to soften the skin and to accelerate the opening of the furuncle and the discharge of the central slough or "core."

Hinton[20] treated over 100 inflammatory conditions with ethylene glycol—magnesium sulfate paste with excellent results and less nursing care than when wet dressings were used. He says:

> [illegible] slowly added to the glycol preparation and thoroughly stirred until the solution becomes adherent to the stirring rod. Then it is transferred to an electric mixer and kept in constant motion for from twenty to twenty-five minutes. A chemical change takes place when the two ingredients are mixed, which is manifested by an elevation of temperature; so the boiling of the ethylene glycol is essential in preparing the paste. One then has a thick paste, which should be allowed to stand for ten days before it is used. The preparation should be stirred daily for five minutes during this period. The paste is of a semisolid consistency and [illegible] with hypertonic properties, so that continuous osmosis will take place in the inflammatory area and by this means the infection will be localized and the edema relieved and as a result the pain greatly diminished, if not entirely overcome."

A most useful proprietary remedy consists essentially of 1 per cent phenol, 9 to 10 per cent fluidextract of ergot and 5 per cent zinc oxide plus a vehicle.* Flaxseed poultices are useful as softening agents but are not aseptic. A method of aborting very early furuncles which is often successful consists in painting the small, red, indurated, painful area with full-strength tincture of iodine. Three or four coats may often be used to advantage, the tincture being allowed to dry between applications.[22]

A valuable agent in the treatment of furuncles is *heat*, particularly in the form of hot fomentations. It is important to give the nurse or attendant explicit directions as to the manner of applying the fomentations. The first requirement is that the dressings be massive so that an area considerably beyond the infected area will be treated. The second requirement is that the dressing be continuously warm and moist. A most convenient procedure consists in applying dressings wrung out of whatever hot solution is employed, covering the dressing with a rubber sheet or oil cloth and fastening an electric pad on top of all (see Fig. 18). By this method a continuous moist heat is produced, and the solution can be added at the corner of the dressing as needed. As a substitute for the electric pad, a hot water bag or frequent changes of the hot dressings may be used. Heat is greatly appreciated by the patient as a rule. In the treatment of carbuncles Livingston[23] uses dry heat after the first twenty-four hours.

Potter[24] believes that the *x*-ray is useful in the treatment of furuncles in a threefold way: first, in the form of a localized erythema dose, to abort incipient boils; second, in the form of local treatment, to hasten the healing and to make well developed furuncles less painful; third, in the form of a wide light exposure, to act as a preventive and prophylactic.[25] Light and Sosman[26] treated 50 carbuncles by roentgen ray. Thirty-four were improved and 16 received no benefit. They believe that when benefit occurred it lay usually in a hastened necrosis of the lesion, a softening or liquefaction of a carbuncle in the indurated stage.

* "Ergophen" (Upjohn).

Following 4 fatal cases of carbuncles in which extensive incision had been done, Laewen,[27] in 1923, began to use *injections of the patient's own blood.* The whole blood was injected at the margins of induration in furuncles after simple crucial incisions. The results were favorable. In contradistinction to Laewen's autogenous blood injections *with* surgical incisions in carbuncles, Carp[28] made an extremely careful study of injections of autogenous blood *without* surgical incisions. He treated 12 nondiabetic subjects with definite progressive carbuncles by the circuminjection of autogenous blood without accessory measures, such as incision, local heat or narcotics. He used a general anesthetic and a sterile needle for each of the three to six intracutaneous and subcutaneous circuminjections. The amount of blood varied from 10 to 70 cc. and averaged 37 cc. Carp noted that (1) the infection did not spread except in 1 case; (2) there was quick relief of the pain and constitutional symptoms; (3) there was no apparent reaction after the injection; (4) most of the slough liquefied; (5) the injected blood seemed to remain in the tissues, undergoing gradual modification for from several days to two weeks; (6) the time for cure was probably shorter than it would have been if a surgical procedure had been used; (7) the patients showed a minimal scar at the time of discharge from the hospital, and (8) the average time to effect a cure was twenty-three days.

The treatment of boils and carbuncles with *bacteriophage* has excited interest. The bacteriophage may be employed as an application to the surface of the infection either as a fluid with appropriate water-proof dressings or in the form of a water-soluble jelly, or the fluid may be injected directly into the infected areas.* Rice[29] has had excellent results in all staphylococcic lesions if there was no bone involvement and if the blood stream was not invaded. Boils and carbuncles showed improvement after the first application. Early boils regressed; later ones became liquid and discharged the core. According to Rice, stock preparations seemed to be just as effective as the bacteriophage prepared from an autogenous culture.

Systemic Treatment

Penicillin has proved useful in the treatment of furuncles and carbuncles. Webb[30] reported on three severe carbuncles of the neck treated with penicillin and hot packs without incision. In one instance a small area of liquefaction was aspirated, and 1 cc. (10,000 units) of penicillin was injected.

Coleman and Sako[31] have had marked success in the treatment of furun cles with penicillin. They say: "The rapid disappearance and cure of multiple furunculosis observed in 6 children under penicillin treatment indicates a result far superior to any previously known therapy for this condition."

Sulfonamides have been used in the treatment of furuncles and carbuncles, and the evidences of their value are somewhat encouraging. Beling and Abel[32] report beneficial results from the use of sulfathiazole and sulfamethylthiazole for 13 patients with carbuncles, 12 with furuncles and 15 with abscesses. These authors emphasize that the sulfonamides do not supplant proper surgical treatment but supplement it.[33]

Vaccines have long been employed in the treatment of furunculosis. They are of the autogenous and polyvalent varieties. The autogenous vaccines are prepared from cultures made from the patient's furuncle and are useful in about 50 per cent of the cases to prevent the development of other boils.

The author has had favorable experience with the use of *staphylococcus toxoid* in furunculosis. In 1933 Dolman[34] reported the "successful treatment of 28 patients suffering from intractable staphylococcic infection with a series of injections of staphylococcus toxoid." In 1 of his cases, after eight injections or a total of 2 cc. of staphylococcus toxoid, the antitoxin titer of the blood had increased 30 times. From four to twenty doses were given. Recurrent

* The water-soluble jelly is obtainable from Eli Lilly & Co., Indianapolis. Abbott Laboratories, Swan-Myers and others prepare the fluid bacteriophage.

furunculosis was particularly benefited.* Jern et al.[36] made a study of the value of staphylococcus toxoid in the treatment and prevention of chronic staphylococcus infections and conclude: "Staphylococcus toxoid, made from toxigenic strains, is able, by means of repeated injections, to increase the antihemolysin titer of the blood and to lessen significantly the incidence of recurrence of furuncles and carbuncles."

Very hopeful is the improved staphylococcus antigen which incorporates the exotoxin of staphylococcus toxoid, as originally produced, and the endotoxic principles from staphylococcus cultures lysed by bacteriophage. Such a product has been termed "staphylococcus bacteriophage toxoid" or "staphylococcus ambotoxoid,"† the latter name being suggested because the product contains both exotoxic and endotoxic principles of staphylococci.

Experimental results from the use of staphylococcus ambotoxoid have been described by Holm, Anderson and Leonard,[37] showing that animals treated with the improved antigen produce higher titers of staphylococcus antitoxin than do those treated with staphylococcus toxoid or with staphylococcus bacteriophage. The animals treated with staphylococcus ambotoxoid also showed better resistance to live cultures of staphylococci given intravenously than did the animals treated with toxoid or bacteriophage. Staphylococcus ambotoxoid should not be used in generalized blood stream infections due to staphylococci; in these cases staphylococcus antitoxin should be employed.

A hopeful aspect of furunculosis is the possible relation of the condition of an *excess of carbohydrates*. The severity of furunculosis in the presence of diabetes is well known, but even when the urine is sugar-free, it is possible that a high normal blood sugar content may increase the liability to furunculosis. On the basis of self experience, Pfahler[38] immediately reduces the carbohydrate diet to a minimum on the appearance of a boil. Bieber,[39] who investigated the blood sugar in furunculosis, used 2 units of insulin daily for four days and says that in four days the furuncles disappeared. Stormer[40] reports good results in furunculosis from the use of 20 to 80 units of insulin daily. Pillsbury and Sternberg[41] found cutaneous infections to be more severe in experimental animals on a high carbohydrate diet.

Williams[42] studied the occurrence of boils and carbuncles in 500 cases of diabetes and concluded that "pyogenic skin infections occur no more frequently in diabetic than in nondiabetic individuals."

In all cases of boils and furuncles, the urine should be tested for the presence of *sugar*. Boils and carbuncles in *diabetic patients* have a far more serious prognosis both for the infection and for the diabetes. In all cases of infections in individuals suffering from diabetes the surgeon should have the assistance and cooperation of an able internist. If possible the urine should be sugar-free at the time of the operation. Diabetic patients are particularly susceptible to two special surgical diseases, namely, carbuncles of the neck and gangrene chiefly of the lower extremities. Maes[43] says that the earlier the treatment is instituted, the better for the patient and the quicker his response to insulin.

White and Cooney[44] have had successful [illegible] carbuncles at the Boston City Hospit[illegible] Bier[45] [illegible] doses [illegible] of sulf[illegible] taining [illegible] day of [illegible] Two are given on the third and the fourth day, three on the fifth and the sixth day and four on the seventh, the eighth and the ninth day. The use of the drug is then continued until there is clinical improvement unless there is ringing in the ears.

Of interest is the treatment of staphylococcic infections with tin and its compounds. Frouin and Gregoire[47] conclude (1) that metallic tin and tin oxide were absorbed by the

* Staphylococcus toxoid may be obtained commercially from Lederle or Squibb, who suggest a table of dosage.

† E. R. Squibb & Sons.

digestive tract, (2) that tin was innocuous to the ingesting animals, (3) that tin had a beneficial effect on staphylococcic septicemia and (4) that the bactericidal action of tin and its compounds justifies its use for patients with staphylococcic infections Gregoire and Frouin[48] produced in stannoxyl a compound composed essentially of metallic tin and tin oxide. They state that they used it successfully in 50 cases of furunculosis and believe that it has a specific action upon the staphylococcus. Other clinical reports are not lacking The dose of stannoxyl is 0. 5 to 1 Gm. (4 to 8 tablets) daily. Levy[49] praised the action of tin in the form of "hordostan." To 40 children under 12 years of age who were suffering from hordeolum he gave from ½ to 1 tablet two to three times daily by mouth.

Carp[50] studied 153 cases of carbuncles at the Presbyterian Hospital, New York, in an effort to compare the merits of four different methods of treatment: (1) *x*-ray irradiation plus accessory therapy, (2) surgical treatment plus accessory therapy, (3) conservative treatment and (4) blood circuminjection without accessory treatment. Because of the dissimilarity of carbuncles and the lack of a definite scheme of tabulation, it is extremely difficult to compare methods of treatment. He presents the following conclusions for consideration:

"1. In large carbuncles, diabetic and nondiabetic, the treatment of choice is radical surgery.

"2. In small, superficial carbuncles and in some large carbuncles, including those of the face, *x*-ray therapy as an aid to conservative therapy (poultices, carbolization, etc.) has given good results. If, however, improvement does not occur in from three to four days, other measures (surgery, circuminjection of autogenous blood) are indicated.

"3. In diabetic carbuncles the prompt establishment of free drainage is essential in order to prevent spread of the infection. *x*-Ray therapy without surgery is contraindicated.

"4. Circuminjection of autogenous blood may be used in selected cases and is a valuable adjunct to the treatment of accessible spreading infections by any other method.

"5. There has been no proof in the clinical cases analyzed in this series that *x*-ray therapy alone effected a cure. Reports in the literature seem to confirm this experience."

Anesthesia

When incision or injection is decided upon in the treatment of furuncles and carbuncles, a choice of anesthetic must be made. The ideal anesthetic is a general one, such as ethylene, nitrous oxide, or sodium pentothal, but is not always available. Ethyl chloride, recommended by Franke,[51] is useful but must be properly applied to produce good anesthesia and to offset the marked danger of gangrene. The surrounding skin must be well protected, and the ethyl chloride must not be applied too long. Mabry[52] lifts the frozen skin with a towel clip before making an incision and from self experience finds it less painful. Sumner Koch strongly disapproves of the use of ethyl chloride. The injection of a local anesthetic is approved by Freeman[53] and Farr[54] but is disapproved by de Takáts[55] and the author. (See section on Local Anesthesia.) Axhausen[56] uses novocain before "glow needle" therapy. Sometimes it is possible to block the sensory nerves supplying the infected area by local anesthesia. For anesthesia of lip and nose furuncles, Klinger[57] has injected 1 per cent novocain into the supraorbital nerves. Wilmoth[58] uses hyosine-morphine anesthesia.[59]

INFECTIOUS GANGRENE

Infectious gangrene of the skin and subcutaneous tissues has been carefully studied and classified by Meleney.[60]

Acute Gangrene

Gas Gangrene.—(See section on Gas Gangrene.)

Hemolytic Streptococcus Gangrene.—This condition was first reported by Meleney,[61] in 1924. It usually follows a trivial injury. There is a sudden onset

of pain and swelling at the site of the injury. The temperature rarely exceeds 102 F., but the pulse is rapid and there is marked prostration. The area of redness spreads rapidly in the first two days, but the margins fade out into normal skin and are not raised as in erysipelas. On the second to fourth days of the disease, the pathognomonic sign of the disease appears. Meleney says: "The sign is a dusky coloring of the skin, appearing in a small purplish patch with irregular and ill-defined margins. It may be some distance from the portal of entry. It has at first a bluish tinge, which makes it distinct from the brilliant redness of the surrounding skin. At the same time a large blister or bulla may appear over this dusky area or somewhere else on the red surface. These areas may extend very rapidly, and changes in them may be seen from hour to hour. . . . Surgery should not be delayed an hour after the diagnosis has been made. . . . As soon as the diagnosis has been made, penicillin should be given in doses varying from 20,000 to 30,000 units every three hours." Longitudinal incisions are made through the gangrenous area extending beyond the limits of necrosis in both directions. Hot poultices are applied for two or three days, and then the wound is irrigated with Dakin's solution through tubes. Sulfanilamide should be given orally.[62]

Diabetic Staphylococcic Gangrene.—Millett and Darby[63] say: "The clinical diagnosis of diabetic staphylococcal gangrene of the skin offers little difficulty once the gangrene appears. In the early stages of the infection it may be mistaken for erysipelas. This diagnosis has been made on several occasions. Another lesion that resembles erysipelas in its early stages and later becomes gangrenous is hemolytic streptococcus gangrene of the skin, described by Meleney. The differentiation is established by bacteriologic examination." Millett and Darby report a case of extensive infectious diabetic gangrene involving the neck. They say: "Infectious diabetic gangrene of the skin may be considered as a separate clinical entity having a distinct clinical course and a definite pathology. In differential diagnosis it must be considered with erysipelas in its early stages and carbuncle in its later stages. Conservative treatment should be given. Penicillin may be life-saving in preventing septicemia or in overcoming it when it occurs."

CHRONIC GANGRENE

Postoperative Progressive Bacterial Synergistic Gangrene.—This condition was first reported in 1924.[64] It usually appears seven to fourteen days after the surgical wound and is characterized by *exquisite tenderness.* The wound becomes red and swollen and in a few days presents a carbuncular appearance. The process spreads peripherally, and as the gangrenous skin liquefies on its inner margin a base of granulation tissue is left behind. (See Fig. 31.) This disease is caused by a microaerophilic non-hemolytic streptococcus, which is combined in the gangrenous skin with a hemolytic Staphylococcus aureus. The treatment is radical removal of the lesion together with the outer zone of redness with scalpel or cautery. Zinc peroxide cream is helpful in preventing a recurrence. Meleney[65] has treated two patients systemically with penicillin, "with prompt and complete subsidence of the inflammation, spontaneous separation of the gangrenous margin and progressive healing without the necessity for wide excision."

Gangrenous Impetigo (Ecthyma).—This disease is found in debilitated ndividuals. The lesions are multiple vesicles which become pustulous and

then gangrenous. The treatment is correction of the undernutrition, together with the administration of ammoniated mercury and sulfonamides. Complete excision is occasionally necessary. Sulfonamides should be tried.

Fusospirochetal Infection of the Skin.—This type of gangrene follows infections developing in wounds made by human bites. Meleney believes that zinc peroxide is the most effective form of treatment either as a prophylactic or after débridement of an established infection.



Fig. 31.—Spreading carbuncular infection of the chest wall. Cured by cautery excision (Christopher, F.: S. Clin. North America 4: 795, 1924.)

Amebic Gangrene (Amebiasis Cutis).—This lesion of the skin may be a wound draining an amebic abscess or it may be in the neighborhood of the anus. The skin becomes indurated and raised with a dark brown color. The necrosis spreads under a foul-smelling exudate. Treatment consists of the administration of emetin and other anti-amebic drugs and the local use of a creamy suspension of zinc peroxide in distilled water. Wyatt and Buchholz[66] report 2 cases, one of which was fatal. In 28 cases collected from the literature by these authors, there were 15 recoveries and 11 deaths; in 2 cases no follow-up study was made.

CHRONIC UNDERMINING ULCER

The credit for establishing this, fortunately rare, condition as a clinical and bacteriologic entity goes to Meleney.[67] He describes the clinical course as follows:

"The disease begins gradually, either at the site of an incised infected lymph gland or in an operative wound associated with the intestinal or the genital tract or in an accidental wound. The lymph gland group occurs in the neck, axilla or groin. The postoperative type generally follows an operation on the intestine, appendix or genital tract. The third type may occur anywhere on the body surface.

"What appears to be an ordinary infection fails to follow the usual course of healing. Improvement, which may have been present in the early stages, gradually ceases. The skin margins slowly become undermined, with liquefaction of the subcutaneous fat and connective tissue and inversion of the margins. There is no gangrene of the skin, but as the undermining progresses, areas in the neighboring skin may take on a dull red or bluish appearance. It is then found that the undermining has extended beneath these areas and the skin has become thinned out as if it were being liquefied from beneath. After a number of weeks a small opening generally appears in these thin areas. These secondary openings gradually enlarge, and may extend until they fuse with the original ulcer, or they may leave a bridge of skin in between which becomes epithelialized on its deep surface. In lower abdominal lesions the undermining frequently spreads down toward the groin or toward the pubic region, extending into the vulva, or into the scrotum, or beneath the crease of the groin into the thigh. In these regions it may burrow deeply, dissecting beneath the muscles and forming deep sinuses into the pelvis. In certain places where the skin is more firmly attached to the deep tissues, such as around the umbilicus or the crest of the ilium, [illegible]

may rapidly melt away. Occasionally these ulcers develop on the leg after a minor injury. In such cases there is always some undermining of the skin margins, but usually they do not undermine extensively in this region."

There is moderate to severe pain and a few degrees of fever. If improperly treated, the condition usually terminates fatally by erosion of a large vessel or by amyloid degeneration of the liver, spleen and kidneys.

The best treatment is the daily application to every part of the wound of a cream made of zinc peroxide, 40 per cent,* and sterile distilled water, 60 per cent. Remote recesses of the wound should be laid open surgically to permit access of the zinc peroxide. The dressing is sealed with vaselin or zinc ointment to prevent evaporation. The wound is irrigated before each application. In a later paper Meleney[68] advises the combined use of local zinc peroxide and oral sulfanilamide 1.2 Gm. every four to six hours. Penicillin has been used without benefit. (Meleney.)

SPECIAL INFECTIONS

Anthrax (malignant pustule) is an infection caused by Bacillus anthracis, and in addition to the cutaneous form there may also occur pulmonary and intestinal types. Anthrax is commonly seen on the neck, face, hands, arms and shoulders of persons who work on hides or sheep skins. Several years ago a number of cases of the disease occurred in this country through the use of infected Japanese shaving brushes. In the cutaneous type the initial lesion is often similar to an incipient furuncle. In many cases it has unfortunately been mistaken for such and incised.

Anthrax begins as an inflammatory papule, accompanied by considerable itching, and then rapidly develops into a pustule on an angry inflammatory base. Induration and inflammation edema surrounding the lesion are so extensive and the constitutional symptoms so severe that one realizes that there is a more serious disturbance than an ordinary pyogenic infection. The

* Zinc peroxide ("medicinal grade") is distributed by Merck & Mallinckrodt. Before being used, it should be sterilized in dry heat of 140° C. for four hours.

pustule rapidly ruptures, leaving a brown or black gangrenous slough in its wake (Fig. 32). There may be and often are a number of vesicles or pustules surrounding this eschar. The neighboring lymph nodes are inflamed and swollen, septicemia rapidly ensues and unless proper treatment is immediately instituted, death occurs within a few days. In this stage the diagnosis can easily be made by examination of direct smears and by means of cultures. Whereas formerly the accepted treatment was excision of the pustule, today surgical intervention is contraindicated. According to Symmers[69] and other authorities, there should be no local treatment but the administration of antianthrax serum. The results following the administration of the serum have been highly successful. If the serum is not procurable, one may employ large doses of neoarsphenamine to advantage,[70] or the antianthracic serum may be given with neoarsphenamine and other arsenic preparations.[71]

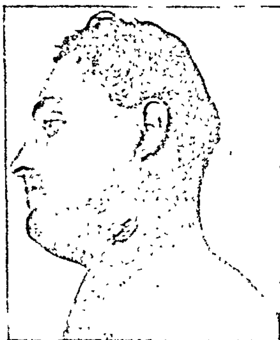


Fig. 32.—Anthrax. (Courtesy of Dr. Edward A. Oliver.)

The experiments of Heilman and Herrell[72] indicate that penicillin is useful in infections with Bacillus anthracis. Gold[73] used sulfonamides in 42 cases, with excellent results in 39. He says that patients should be treated intensively with sulfapyridine and sulfathiazole, but if they fail to respond after three days, antianthrax serum should be used. Sulfathiazole is the drug of choice. Gold believes that the illness was definitely shortened in his cases by the use of sulfonamides and that the sulfonamides are a safe and reliable substitute for serum and should be given preference in the treatment of anthrax. Ellingson et al.[74] report recovery of 25 patients with cutaneous anthrax after administration of total dosages of 1,000,000 to 4,000,000 units of penicillin.

Lucchesi and Gildersleeve[75] report on the treatment of 67 patients with anthrax without a death. They say: "Of the treatments employed in this study we definitely favor the neoarsphenamine, because it best fits the ideals for treatment which we have enumerated previously. However, if the patient is afflicted with the internal type of anthrax, if the blood stream has been invaded or if the lesion is on the face or neck, serum is the agent of choice.

If there is any doubt as to the type of treatment desired, one should give serum." They conclude: "1. Forty-eight patients with anthrax were treated as follows: (a) 19 with serum; (b) 10 with neoarsphenamine; (c) 15 with serum and neoarsphenamine; (d) 3 with sulfanilamide, and (e) 1 with sulfanilamide, serum and neoarsphenamine. 2. Neoarsphenamine gave the best results in selected cases. 3. The dictum 'hands off the local lesion' should be strictly adhered to."

Actinomycosis is caused by Streptothrix actinomyces, or ray fungus, a vegetable fungus. This organism is generally encountered as a saprophyte on hay, wheat, oats and barley. In many cases a direct history of chewing grass or straw can be obtained from the patient. It is a disease of early adult life. Of 450 patients at the Mayo Clinic, 3 per cent were between the ages of 2 to 15 years.[76] The diagnosis is established by finding the ray fungus and sulfur-



Fig. 33.—Actinomycosis. (Courtesy of Dr. Edward A. Oliver.)

like granules in material from the lesion. The commonest locations of the affection are the tissues about the face and neck, though abdominal and pulmonary infections are seen (Fig. 33). Its occurrence has been reported on the tongue,[77] in the tibia[78] and in the meninges, the primary focus being a finger.[79] Infection commonly occurs through the mouth, chiefly through decayed teeth. The incubation period of the disease is variable. Sometimes several months may intervene before the development of the subcutaneous nodules or groups of nodules. Its typical development is seen best in the cervical type of the disease, in which nodules varying in size from a hickory nut to a walnut develop about the jaw and in the submaxillary region. They rapidly increase in number, coalesce and form dark red patches and infiltrations, beset with numerous sinuses and areas of bleeding granulation tissue. These lesions are generally painless. Constitutional symptoms are very rarely

noted unless the disease is complicated by the involvement of deeper structures or through the development of septicemia.

Surgical measures are of great value in the early stage. If practicable, complete excision of the involved area should be done. If the patient is not seen until there is extensive tumor development, surgical treatment should consist of free opening and curettement of the fistulous tracts.

Wangensteen,[80] who has a large experience in the treatment of actinomycosis, says: "The most direct agency in the treatment of actinomycosis is surgery. The rationale of the surgical treatment lies in the fact that the infection is essentially an anaerobic one. Removal of the dead tissue, which is poorly oxygenated and in consequence an excellent culture medium, will usually terminate the disease. Many instances of cervicofacial actinomycosis respond favorably to curettement alone. In extensive cases, energetic surgical excision of devitalized tissue is indicated."

Sulfanilamide has been found to be of some value in the treatment of actinomycosis. Walker[81] reported a case of abdominal actinomycosis which was refractory to potassium iodide but which responded dramatically to sulfanilamide. In January 1939, Dr. Edwin M. Miller presented before the Chicago Surgical Society a remarkable case of abdominal actinomycosis cured with sulfanilamide.[82] Penicillin is useful in actinomycosis. Walker and Hamilton[83] treated six patients with favorable results. The treatment should be prolonged, and "surgical excision should be used as an adjunct to penicillin therapy when there is marked fibrosis and scarring, which is amenable to it." They say that "there is little doubt that today penicillin is the most effective therapeutic agent we have in the treatment of actinomycosis." Two favorable cases are reported by Jones and Brownell.[84] Dobson, Holman and Cutting[85] report the complete cure of three cases of actinomycosis. One was of the jaw, one of the lungs and rib cage and one of the abdomen. The therapy included sulfanilamide, iodides and roentgen rays. They advise that one of the sulfonamides should always be used in the treatment of actinomycosis. Potassium iodide may have some value. In many cases *x*-ray therapy will prove of distinct service. The administration of thymol orally and its use in the wound in actinomycosis have been commended by Bancroft and Stanley-Brown,[86] Joyce[87] and Myers.[88]

Blastomycosis is a chronic infectious disease caused by a yeast fungus. It may either affect the skin alone or be a systemic infection. Dermatologic cases are far more common than those of the systemic variety. The disease is uncommon in America except in the vicinity of Chicago, where many cases are encountered (Fig. 34).

Blastomycosis of the skin begins as a small pea-sized papule or papulopustule. The lesion spreads peripherally and grows rather rapidly. In any one case one may see some small pea-sized lesions or several larger patches. Whatever the size of the lesion, the characteristics are the same. It is practically painless, its top is generally rough, with warty, papillomatous vegetations, its base is soft and pressure on the lesion causes droplets of pus to exude from between the surface papillae. The lesion is definitely raised from $\frac{1}{4}$ to $\frac{1}{2}$ inch above the surrounding skin and has a sloping inflammatory border in which are seen, generally with the aid of a hand glass, minute abscesses the size of the point or head of a pin. In these abscesses the organism is readily found.

The pus is best examined by spreading a little on a glass slide, moistening

it with 15 per cent potassium hydroxide solution and then examining it under the high dry power of the microscope.

Smith[89] says: "The clinical characteristics of blastomycosis of Gilchrist and the group of other mycoses in which yeast-like bodies are found are often not sufficient for diagnosis. In some forms of the group the microscopic appearance of the organism may be characteristic and diagnostic, but in most cases the study of cultures is necessary. An accurate mycologic diagnosis is important in view of the different prognoses and the varying degree of therapeutic response of infections by these different fungi, and for the purpose of adding new members to the list of possible pathogens. Intracutaneous tests with fungous antigens offer some assistance in diagnosis but must not be considered absolutely specific."

The disease may occur anywhere on the body but most commonly affects the skin of the face and hands. The region about the lower eyelids is commonly affected. One so often sees lesions in diverse portions of the body that there is no doubt that the condition is spread by autoinoculation.



Fig. 34.—Blastomycosis of the face. (Courtesy of Dr. Edward A. Oliver.)

Systemic blastomycosis, while not nearly so common as blastomycotic dermatitis, does occur. Almost any organ in the body may be affected, but the disease most commonly attacks the lungs. It seldom follows the cutaneous type. Most cases occur without any preceding dermatologic manifestations. This type of the disease is often mistaken for tuberculosis, and a definite diagnosis can be made only by finding the organism. Rypins[90] has made a study of blastomycosis of the skeletal system.

The *prognosis* in both types is serious. Nearly all the cases of the systemic type and even those of the cutaneous type are fatal. Recurrences are common, and the disease often taxes all of one's resources.

The *treatment* is principally medicinal. Potassium iodide in large doses always should be given. Neoarsphenamine is also of value, as are also roentgen therapy and radiotherapy and occasionally surgical intervention. Jackson[91] treated 2 cases of extensive blastomycotic skin lesions by thoroughly cooking

the area to a depth of 3 or 4 cm. by means of large soldering irons heated to a dull red. The cooked surface was then curetted until blood appeared, when the irons were again applied. This procedure was repeated until all evidence of the disease had been removed. At the conclusion of the operation a hot wet dressing of 1 per cent copper sulfate solution was applied. Balsam of Peru is useful for the granulating area. Hedge[92] has successfully treated 2 cases of blastomycosis with carbon dioxide snow. Locally the best application to use is one of a 1 per cent copper sulfate solution.

Sporotrichosis is a granulomatous disease involving the skin and subcutaneous tissues caused by *Sporothrix schencki.* Meyer and Weiss[93] report 2 cases of osseous sporotrichosis.[94]

The disease, while not common, is not considered a rarity. The organism responsible for the disease most often gains entrance through a wound of the finger or hand (Fig. 35). After several weeks this wound is followed by the development of a chain of subcutaneous nodules up the lymphatics of the arms. These nodules vary in size from that of a split pea to that of a cherry,



Fig. 35.—Sporotrichotic chancre (Lawless, T. K.: Arch. Dermat. & Syph. 22: 381, 1930.)

develop slowly and may break down, forming sporotrichial gummas. They give rise to little pain and respond readily to treatment. If gummas have resulted from the breaking down of the nodules, healing occurs, with rather marked scar formation.

Occasionally bones have been involved. The disease markedly resembles tuberculosis and tularemia, and only by cultural methods can an exact diagnosis be made. According to Lawless,[95] the laboratory diagnosis is made by "(1) direct smears from the punctured nodules; (2) cultures on Sabouraud's mediums with special reference to the hanging drop method—1 drop of sugar solution and 1 drop of pus; (3) the seroagglutination and the complement-fixation reactions, and (4) the cutireaction and the intradermal reaction."

Treatment.—The disease readily responds to treatment with fairly large doses of potassium iodide.

Tularemia is a disease caused by Bacterium tularense (Pasteurella tularensis). The disease is not contagious from man to man but is carried by the wood tick, deer fly and the wild cotton-tail rabbit. In the 225 cases analyzed by Pullen and Stuart[96] "176 patients gave a history of definite contact with

rabbits, 6 to ticks, 3 to squirrels and 1 each to mink, raccoon, opossum, dog, cat and rat. In 34 instances a definite contact was not established." Warring and Ruffin[97] report on an epidemic of tularemia, and in 32 of the 50 cases a history of tick bites was obtained. Kirkwood[98] reports a case contracted from a fox squirrel. McDaniels[99] states that the wild animals in which tularemia has been found and which are native in the state of Illinois are cotton-tail rabbit, wild rat, muskrat, opossum, coyote, quail, fox, squirrel and woodchuck. This writer says that "domestic animals, especially dogs, cats, and hogs, may contaminate their mouth parts by eating dead or dying rabbits, and may later transmit tularemia by means of a bite." In Illinois 98.3 per cent of the cases were due to handling infected rabbits. According to Simpson,[100] "the greatest number of cases have occurred in market men who have skinned or dressed rabbits; in housewives or servants who have dressed rabbits for the



Fig. 36.—Primary cutaneous lesions of tularemia: (A) a primary papule on the seventh day; (B) a primary papule showing beginning liberation of the necrotic core on the fourteenth day; (C) a primary ulcer after liberation of the necrotic core on the twenty-first day; (D) a primary ulcer on the forty-second day. (Kavanaugh, C. N.: Arch. Int. Med. 55: 61, 1935.)

table; in hunters who have dressed rabbits during the hunt, and in farmers or ranchers who have picked infected flies or ticks from their horses or cattle or who have cut up jack-rabbits for fish bait, coyote bait or food for domestic animals."[101] Hillman and Morgan[102] report a fulminant epidemic of tularemia transmitted by the deer fly. There have been reports of tularemia following ingestion of uncooked or partly cooked rabbit.

There are four clinical types of the disease: (*a*) The ulceroglandular type, which comprises two thirds of the cases. In this there is a papule at the point of inoculation, usually the finger or hand (Fig. 36). The papule becomes painful and swollen and suppurates, liberating a necrotic core and leaving an ulcer (Simpson). The regional lymph glands become hard and may suppurate. The patient has severe "griplike" symptoms and may become delirious. (*b*) The oculoglandular type, with the primary localization in the conjunctiva.

(c) The glandular type with no visible primary lesion. (d) The typhoid type, in which the outstanding symptom is fever. McDaniels[99] studied 200 cases in Illinois. The incubation period could be determined in 96 cases. It varied from 1 to 21 days, with an average of 6.1 days. In 124 cases the duration of the disease varied from 16 to 360 days. In three quarters of the group the duration was 3 months or less. The mortality in 134 cases was 3.7 per cent. In the 225 cases studied by Pullen and Stuart[96] there were 17 deaths from tularemia, a mortality of 7.55 per cent. The chief cause of death in tularemia, according to Foshay,[103] is septicemia due to Bacterium tularense.

The diagnosis is made by the history and the highly specific Bacterium tularense agglutination reaction. The goat antitularense serum developed by Foshay[104] gives a means of providing a reliable specific therapeutic agent against tularemia (Simpson). Foshay[105] states that the intradermal test is the earliest available diagnostic aid for determining the presence of tularemia. The use of immune human serum appears to have a favorable effect on the course of the disease.[106] The experimental work of Heilman[107] indicates that *streptomycin* has considerable activity against the organism of tularemia. Sulfonamides have been used with variable success.[108] Abel[109] reports 3 cases of tularemia treated with streptomycin and says: "Streptomycin appears specific for tularemia, as evidenced by the rapid improvement immediately following its use. There were no reactions noted. The dose of streptomycin is not known, but it seems to be regulated by the severity of the disease." Howe et al.[110] had favorable results in the treatment with streptomycin of 7 cases of tularemia. The paper by Foshay and his associates is a report of studies on vaccine prophylaxis against tularemia.

According to Simpson,[106] "it is useless to incise the primary lesion, and it is unwise to excise, or even incise, the enlarged lymph nodes until definite suppuration is present. The prophylactic treatment is important."

Tuberculosis Verrucosa Cutis.—While this may occur any place on the skin, its commonest locations are on the backs of the hands and fingers. It is always due to inoculation with the tubercle bacillus and is frequently seen in meat handlers or in pathologists. One type of lesion is called the "*anatomic tubercle*" or "*postmortem wart.*" This is situated on the fingers or hands and is often the size of a dime. Larger patches may also occur. The patch is generally elevated, infiltrated, wartlike, dark red or purplish, and resembles to some degree the lesion of blastomycosis. It is generally dry and productive of no sensation, it grows slowly, lasting for years, and occasionally it disappears spontaneously. The small lesions may be excised; the larger ones are best treated by the use of 10 per cent salicylic acid ointment or by exposures to the *x*-ray.

Syphilis.—Syphilitic infection may occur as the result of accidental wounds incurred in operations or autopsies. Kanavel and Koch[112] say:

> "[illegible]
> [illegible]
> mortem examination. The immediate symptoms were those of an acute pyogenic infection
> [illegible]
> of a syphilitic infection remembered.

"Any wound incurred during the course of an operation or postmortem examination which does not heal within a week's time should suggest the possibility of a syphilitic infection."

Syphilitic gummas may occur anywhere on the skin. Their common sites, however, are on the legs, forehead and sternal region. Gummas on the legs



Fig. 37.—Gumma. (Courtesy of Dr. Edward A. Oliver.)





Fig. 38.—Lupus vulgaris, before operation and two weeks after excision and plastic covering of the defect with the skin of the neck. (Kurtzahn, H.: Kleine Chirurgie, Berlin, Urban & Schwarzenberg, 1929.)

are generally on the upper and posterior aspect. They usually are single but may be multiple (Fig. 37). They begin deep in the tissues as nodules the size of a pea or nut, they generally increase in size and as they approach the surface, the overlying skin becomes dark red or purplish. The skin softens and gives way, and a cleancut, punched-out ulcer is the result (Fig. 39). Secondary

infection rarely occurs. Surgical treatment is distinctly contraindicated; the lesions heal promptly under antiluetic therapy.



Fig. 39.—Tertiary syphilis. Multiple gummas of the leg. (Courtesy of Dr. Edward A. Oliver)

Coccidioidomycosis (Coccidioidal Granuloma).—This is an acute or chronic infection caused by the fungus Coccidioides immitis and is most commonly found in the San Joaquin Valley, California. Quill and Burch[113] say that the



Fig. 40.—Aspergillus infection of the hand. (Myers, J. T., and Dunn, A. D.: J. A. M. A. 95: 794, 1930.)

disease is also endemic in certain regions of Arizona, New Mexico, Mexico and Texas. In addition to involvement of the respiratory tract, subcutaneous abscesses, verrucous lesions, granulomatous nodules, or indolent ulcers may

be found. It may occur in bone.[114] The diagnosis is made by identification of the organism and the coccidioidin test. The treatment is the same as that for tuberculosis. Abscesses may be excised or drained. Of the drugs employed, antimony, potassium tartrate, thymol and colloidal copper seem to have some value.[115] Sulfonamides have not been found to have value.

Aspergillus Infection.—Myers and Dunn[116] isolated Aspergillus terrens from an indolent ulcerative lesion of the hand and produced similar lesions in laboratory animals by subcutaneous inoculation of the organisms. In their case, rapid healing of the lesion on the hand, which had resisted varied treatments for two years, followed the application of 1 per cent copper sulfate solution alternating with 1 per cent copper subacetate ointment (Fig. 40). A case of postoperative skin infection by aspergillus is reported by Frank and Alton.[117]

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CHAPTER IV

BURNS

While the subject of burns has always been one of importance, the great increase of burn casualties in World War II has directed considerable interest and study in this direction. Many valuable additions to the knowledge of burn treatment have been made in recent years.[1]

Burns may occur from contact with flames, hot solids (hot water bags!), hot air, hot liquids or steam, from exposure to sunlight or ultraviolet light, and from acids, alkalis, electricity, roentgen rays, radium, caustic substances of various kinds and irritant gases (Schamberg[2]). A *scald* is the reaction of the tissues to moist heat. Fox[3] reported 6 cases of third degree burns of the scalp following ignition of celluloid combs which were used by women in waving the hair. He warns that "celluloid combs should never be used when heat is applied to dry the hair."

In this country it has become customary to classify burns into three grades according to the depth: first degree, erythema; second degree, vesicle formation, and third degree, complete involvement of the skin or underlying structures. In England and France it is usual to divide burns into the six degrees of Dupuytren's classification: first degree, superficial congestion; second degree, bleb formation; third degree, destruction of cuticle with exposure of the nerve terminals—the most painful form of burn; fourth degree, destruction of the whole thickness of the skin; fifth degree, encroachment on the muscles, and sixth degree, involvement of an entire limb. Lehman[4] points out that the diagnosis of the one thing that is of importance in the prognosis as to morbidity of a burn, namely, the depth of the burn in relation to the full or partial thickness of the skin, is impossible at the time many burns are first seen. Dingwall[5] has injected intravenously not more than 10 cc. of 20 per cent sodium fluorescein in an effort to differentiate second from third degree burns. He then viewed each area under ultraviolet light with a Wood filter. In third degree burns the burned areas appeared as sharply demarcated blue-black patches in contrast to the surrounding yellow-green color of normal fluorescein-containing skin. In second degree burns the burned areas showed a yellow-green color that was generally more intense than that of the surrounding skin. Lehman proposes the following classification of burns, which is based almost entirely upon the problems of treatment:

"[illegible] classified [illegible]

a Group I burn can be made on first inspection.

"Group II. All burns involving loss of substance in which the loss nowhere includes the full thickness of the skin. This group requires protection from damage and contamination, takes somewhat longer to heal than Group I, but does not require skin grafting for a satisfactory result. It cannot be diagnosed until after sloughing has occurred.

"Group III. This burn includes the full thickness of the skin and any structures beneath

it requires skin grafting for a satisfactory result. It also cannot be diagnosed until removal of the slough. Many, if not most, of Group III burns will present peripheral or central areas of Group I and Group II destruction. This latter fact is of no practical significance since these areas will declare themselves before skin grafting can be undertaken."

According to Pack[6] and MacLeod,[7] the extent of a burn is more important than the depth. Burns of first degree are usually fatal if two thirds of the body surface is involved,[8] and, generally, all burns of second degree are fatal in adults if one third of the body surface is involved and in children if one seventh is involved.[9] All burns covering one third of the body surface are extremely serious, if not immediately fatal. All burns involving one tenth of

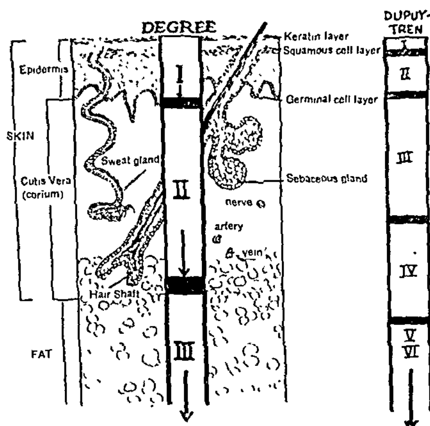


Fig. 41.—D... degrees. *Left*, according to Natic... Dupuytren. (Modified from Nation... I. H., Morgan, E. M., and Farmer, ...)

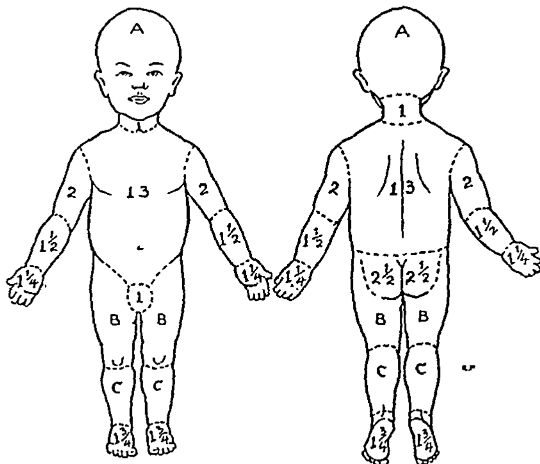
the body surface should be considered serious (Pack[6]). Berkow's[10] work is useful in the estimation of the extent of surface lesions. He concludes that the lower extremities, including the buttocks, comprise 38 per cent of the body surface; the trunk, including the neck, 38 per cent; the upper extremities, 18 per cent, and the head, 6 per cent. The hand is one quarter of an upper extremity and the arm three quarters. Of the lower extremity, the foot is one sixth, the leg one third and the thigh one half. Lund and Browder[11] find that "certain systematic errors of magnitude" can occur when Berkow's table for adults is applied to children. Their new table of surface proportions of the body is reproduced herewith, and from this table Lund and Browder have prepared the valuable charts shown in Figures 42 and 43."

It would seem highly desirable that in the future burns be classified by both extent and depth, for example, a 30 per cent second degree burn, a 10 per cent

BOSTON CITY HOSPITAL

Name ______________________ Age ________ Number ________

Burn Record. Ages—Birth—7½ Date of Observation ______________________



RELATIVE PERCENTAGES OF AREAS AFFECTED BY GROWTH

Area	Age 0	1	5
A = ½ of Head	9½	8½	6½
B = ½ of One Thigh	2¾	3¼	4
C = ½ of One Leg	2½	2½	2¾

% BURN BY AREAS

Probable 3rd° Burn { Head ______ Neck ______ Body ______ Up. Arm ______ Forearm ______ Hands ______
Genitals ______ Buttocks ______ Thighs ______ Legs ______ Feet ______

Total Burn { Head ______ Neck ______ Body ______ Up. Arm ______ Forearm ______ Hands ______
Genitals ______ Buttocks ______ Thighs ______ Legs ______ Feet ______

Sum of All Areas Probably 3rd° ______________ Total Burn ______________

Fig. 42.—Chart prepared for children. (Lund and Browder: Surg., Gynec. & Obst. 79: 356, 1944.)

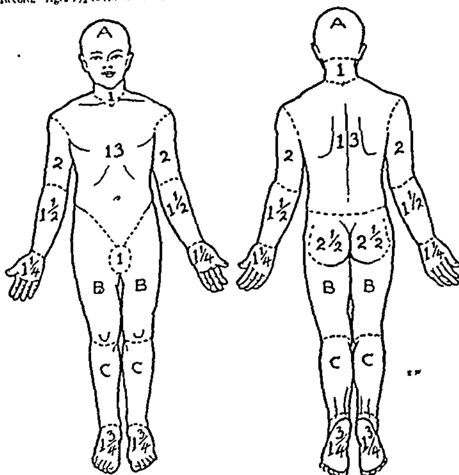
third degree or a 25 per cent second degree burn. It is to be remembered that other things being equal, burns in children and infants are more serious than

those in adults. Forty-five *per cent* of the deaths from burns occur during the period from birth to the fifth year.[12] Accidental burns (those due to

BOSTON CITY HOSPITAL

Name ________________________ Age ________ Number ________

Burn Record. Ages 7½ to Adult. Date of Observation ________________________



RELATIVE PERCENTAGES OF AREAS AFFECTED BY GROWTH

Area	Age 10	15	Adult
A = ½ of Head	5½	4½	3½
B = ½ of One Thigh	4¼	4½	4¾
C = ½ of One Leg	3	3¼	3½

% BURN BY AREAS

Probable 3rd° Burn	Head ____	Neck ____	Body ____	Up Arm ____	Forearm ____	Hands ____
	Genitals ____	Buttocks ____	Thighs ____	Legs ____	Feet ____	
Total Burn	Head ____	Neck ____	Body ____	Up. Arm ____	Forearm ____	Hands ____
	Genitals ____	Buttocks ____	Thighs ____	Legs ____	Feet ____	

Sum of All Areas   Probably 3rd° ________________ Total Burn ________________

Fig. 43.—Chart prepared for adults. (Lund and Browder: Surg., Gynec. & Obst. 79. *357, 1944.*)

conflagrations being excepted) are the leading cause of death at the ages of 1, 2 and 3 years and for all the ages under 5 years.[13]

TABLE OF SURFACE PROPORTIONS [PERCENTAGES] IN DETAIL

(Lund and Browder)

Age	Birth	1	5	10	15	Adult
Area:						
Head	19	17	13	11	9	7
Neck	2	2	2	2	2	2
Anterior trunk*	13	13	13	13	13	13
Posterior trunk†	13	13	13	13	13	13
Buttocks	5	5	5	5	5	5
Genitalia	1	1	1	1	1	1
Upper arms	8	8	8	8	8	8
Forearms	6	6	6	6	6	6
Hands	5	5	5	5	5	5
Thighs	11	13	16	17	18	19
Legs	10	10	11	12	13	14
Feet	7	7	7	7	7	7
Total	100	100	100	100	100	100

* Without neck or genitalia.
† Without neck or buttocks

THE PATHOLOGY OF BURNS

Aside from the burned area, there are numerous pathologic changes in burned patients. Fatty degeneration and necrosis of the *liver* have been frequently noted.[14] Erb and his associates[15] studied the postmortem findings in 61 fatal cases of burns. Of the 41 cases in which tannic acid treatment was given, 25 (61 per cent) showed liver necrosis, and no cases of liver necrosis were found in the group of cases in which tannic acid was not employed.[16] Saltonstall et al.[17] conclude that hepatic damage is probably not the primary cause of death in burn toxemia. They[18] state that "damage to the liver, both functionally and histologically, is usually mild if tanning agents are not used in the local treatment of the burned surface." (See section on tannic acid treatment.) Changes in the adrenal glands are common. In cases of extensive burns, the adrenal glands weigh from three to five times normal, and the epinephrine content is depleted or low.[19] Olbrycht[20] states that in severe burns in man and animals there are changes in the adrenals and that the intensity of the hyperemia and ecchymosis and the reduction or total loss of chromaffin substance and lipoid in these glands seem to depend upon the extent of the burned area and the age of the subject, being most pronounced in the young. *Gastrointestinal ulceration* (Curling's ulcer) is not uncommon, particularly in a severe third degree type of sloughing and sepsis.[21] The incidence in 680 fatal cases was 3.8 per cent. There is also inconstant damage to he kidneys, heart, lungs and other organs.[22]

Johnson[23] has found *carcinoma* in the *scar tissue* following burns

Treves and Pack[24] studied 2465 cases of skin cancer, treated at the Memorial Hospital, New York. There were 1091 cases of epidermoid carcinoma and 1374 cases of basal cell carcinoma. These cancers developed in burn scars in 28 instances; 21 were epidermoid carcinomas and 7 were basal cell epitheliomas. From these data they estimate that "2 per cent of all epidermoid carcinomas and 0 3 per cent of all basal cell carcinomas originate on

skin subjected to thermal injuries. The tight thick scar from a burn is the one most liable to carcinomatous degeneration. Ulcerations forming on burn contractures may lead to carcinomatous change.

"In burns of a severe degree skin grafting is the most efficient preventive measure. When skin grafting is delayed, unhealthy granulations with a scar tissue base develop. It is important to employ skin grafting in the burns sustained by children, not only for cosmetic and functional results but because the exuberant scars which form in young individuals are more prone to degenerate later in life. The types of skin grafts to be used will depend upon the severity, extent, and location of the burn.

"Scars which have formed, especially large ones, are menaces. They must be safeguarded against irritation and trauma. If dry they should be occasionally treated with a bland oil or ointment to prevent excessive keratin accumulation."

THE PATHOLOGIC PHYSIOLOGY OF THE EXTENSIVELY BURNED PATIENT

Shock.—Shock in burned patients may be divided into primary and secondary, but often such a distinction is not possible, as the two conditions are merged into one. *Primary shock* is largely caused by pain.[25] *Secondary shock* is due to the large *loss of plasma* into the tissues in and surrounding the burned area and to a smaller loss of plasma to the exterior and in other parts of the body. The fluid imbalance occurs during the first few hours. Capillary stasis and altered permeability in the burned area permit the passage of plasma protein across the capillary membrane with a corresponding disturbance of the osmotic pressure relationship. As a result, tissue fluids are increased and plasma volume is diminished; this is a fluid imbalance or abnormal distribution of fluid rather than an external loss.[26] McClure[27] studied the evaporation of water from superficial burns and concluded that "evaporation has a negligible effect in producing dehydration after a severe burn."[28] This plasma loss is evidenced by a marked *hemoconcentration*. Pack,[29] basing his belief on his work with Underhill,[30] feels that a 40 per cent increase in hemoglobin, if maintained for any length of time, is incompatible with life.[31] The pulse is weak and the blood pressure falls. Prinzmetal et al.[32] believe that there are at least two mechanisms capable of producing burn shock, *viz.*, one due to local fluid loss and one due to some unknown factor. Abbott et al.[33] find that after the shock phase there is an increase in the total circulating plasma proteins, although a negative nitrogen balance may exist for two or three weeks. They advise against administration of excessive quantities of fluid in the post-shock period.

Toxemia.—The presence of a toxin liberated from the burned area is still undecided. It is possible that such a toxin may be histamine.[34] Toxemia, if existent, is more likely to be a factor after the third day.[35] Elman and Lischer[36] stress the importance of differentiating wet and dry necrosis in human burns and suggest that wet necrosis may produce "toxic" manifestations.

Proteins.—Lund and his associates[37] call attention to the severe hypoproteinemia which occurs on or before the fifth day after a serious burn. There is an excessive measurable loss of nitrogen in the urine as well as losses of unknown amounts from the body surface. The loss of nitrogenous substances is so great that intravenous plasma, albumin and blood cannot possibly cope with it. Very high protein diets are indicated, but anorexia may interfere with the success in this regard. In some cases intravenous or oral administration of amino acids is of vital importance. In one severe case of third degree burn of 50 per cent of the body area, Lund and his associates reported that the nitrogen balance was reached on an intake of 300 Gm. of protein (or equiva-

lent) per day. Rapid improvement of the condition followed raising this intake to 500 Gm. (equivalent to 10 pounds of meat per day).

Chlorides.—Davidson[38] showed a lowering of the whole blood and plasma chlorides which is proportionate to the amount of tissue devitalized and which is present as long as sloughs are present. On this account Davidson suggested sodium chloride administration.

Liver Function.—Saltonstall and his associates[17] studied liver function in burns and found that tannic acid and to a lesser extent other tanning methods impaired liver function following burns. Mild impairment of liver function occurred in patients treated with petrolatum gauze and pressure dressings. Abandonment of the use of tannic acid in the local treatment of burns did not result in a decrease in the mortality rate in their series, and they think it "unlikely that the increase in liver damage observed when tannic acid is used is of great significance in the mortality among burn patients."

Central Nervous System.—Walker and Shenkin,[39] from microscopic studies of six fatal burn cases, suggest that "the central nervous system changes are an important factor in the explanation of the sudden deaths in the toxemic phase of burns."

Carbohydrate Metabolism.—Taylor et al.[40] found that 21 of 35 burned patients had hyperglycemia.

Non-Protein Nitrogen.—Walker[41] found "a marked rise in plasma non-protein nitrogen within two to six days following thermal burns."

Rose and Browne[42] have shown that there is a decrease in blood histamine in severe burns as toxemia and edema appear. Goldblatt[43] has reported three cases of tetanus in eighty-three cases of burns.

GENERAL TREATMENT OF BURNS*

First Aid.—"A large proportion of burns are sterile or nearly sterile at the moment they occur. Every practicable effort should be made to maintain asepsis."[44] The patient and those taking care of him should be warned not to touch or otherwise contaminate the burned area. Attendants should be masked or at least should wear a handkerchief over the mouth and nose. A sterile dressing only or at least a clean cloth should be placed over the burned area and the patient quickly transported to the place where formal treatment can be carried out. Light frosting of the burned area with sulfadiazine or sulfathiazole powder is permissible. The English recommend triple dye jelly or gentian violet jelly for first-aid treatment. (See section on war burns.) No ointments, greases or coagulating agents should be applied as a first-aid measure. Morphine, in dosage adequate to control pain ($\frac{1}{4}$ to $\frac{1}{2}$ grain for an adult), should be given as quickly as possible. The patient should be adequately covered to prevent chilling. When possible and practicable, 500 cc. of blood plasma may be given intravenously.[45]

Primary Shock.—The primary shock in extensive burns is similar to any surgical shock. A blunted sensibility, cold moist [illegible] rectal temperature, irregular sighing [illegible] rapid [illegible] and very low

* Students are urged to read th[illegible] [illegible]venson, S. [illegible] W., and Lund, C. C.: An Outline for the Tre[illegible] [illegible], New [illegible] 235: 76, 1946. Lange, H. J.; Campbell, K. N., [illegible] Present [illegible] of the Severely Burned Patient: An [illegible] Transfusions, J. Michigan M. Soc.

blood pressure are noted. Morphine is given in dosage adequate to control pain. Removal of the clothing may be shocking, and great care must be exercised in carrying this out.

Secondary Shock (Burn Shock).—This phase of shock may begin almost immediately after the burn or may be delayed for several hours or days. It is based on the shift of the body fluids described previously, with a resultant decrease in the fluid fraction of the blood. Harkins et al.[46] say: "The signs of burn shock are often very misleading until just before collapse occurs. Thus, shock is often present when a patient looks and acts quite well. Generalized vasoconstriction may keep the blood pressure at satisfactory levels even though cardiac output is greatly diminished. Therefore in the early hours the presence of shock is to be assumed in all severely burned patients despite a satisfactory clinical appearance. If one waits for cold extremities, cyanosis and collapsed veins, therapy is apt to be ineffective. This period of shock (to forty-eight hours after burn) is also essentially the period of vigorous fluid therapy. Subsequently adequate fluid therapy and vigorous food therapy may be indicated, but in a case treated sufficiently during the first two days there is no routine indication for extensive forcing of fluids after that time." The plasma lost from the blood into the tissue spaces must be replaced promptly. The initial reduction in the plasma volume usually occurs within six hours after the burn but may be very rapid. Elkinton and his associates[47] found a 20 per cent reduction in fifteen minutes after a 20 per cent second and third degree burn. Rhoads and his associates[48] were unable to aspirate a cubic centimeter of blood from the incised anterior tibial vein at the ankle about forty-five minutes after a 65 per cent burn. The plasma leakage may continue for three or four days. "It is generally agreed that in burns which involve less than 10 per cent of the body surface there is not sufficient loss of extracellular fluid to warrant intensive fluid therapy."[46]

The need for water and electrolytes is moderate, as they may be supplied from the tissues when the plasma osmotic pressure is restored to normal. "Blood plasma is the best treatment known at the present time for the treatment of burn shock."[49] Intravenous glucose and saline solutions accomplish little and may be harmful. With their administration the plasma protein levels may decrease and the hemoconcentration and edema increase. The use of blood in the early period may be actually harmful, for the plasma continues to be lost and the red cells remain in circulation. "This leads to hemoconcentration and an increased viscosity of the blood, to a deficient oxygen carrier, greater work on the heart, and thus to an intensification of the shock."[50] Blood transfusions are permissible in burn cases only when there has been a severe loss of blood from a wound. On the other hand Evans and Bigger[51] have found that, "apparently, whole blood can be given safely to burn patients with hemoconcentration. If adequate amounts of whole blood are given initially in severely burned patients, secondary anemia is regularly avoided." Cope[52] says: "The wound enlarges the body's reservoir for water, electrolyte and protein. All three should be given in the treatment of shock and in amounts sufficient to restore their normal concentrations. When water only is given, the electrolyte and protein in the plasma and interstitial space become dilute, but water alone is better than no treatment at all. Water and salt will fill the reservoir, but only when plasma protein is given in conjunction does the plasma volume possess an adequate colloid osmotic pressure."

Amount of plasma to be given a severely burned patient: Harkins et al.[46] say: "If superficial arm veins are inaccessible, femoral vein puncture, saphenous vein cannulization in the foot, ankle, leg, or even at the fossa ovalis, or intramedullary injections may be necessary." These workers have furnished us with the following formulas for guidance in plasma administration:

"(*a*) Formulas dependent on extent of hemoconcentration: (1) Give 150 cc. of plasma for each specific gravity increase of 0.001 above the normal whole blood specific gravity of 1.060 (i. e., if the specific gravity of whole blood is 1.070, give 1500 cc. of plasma); (2) or give 100 cc. of plasma for each point the hematocrit exceeds the normal of 45 (i. e., if the hematocrit is 60, give 1500 cc. of plasma); (3) or 50 cc. of plasma for each point the hemoglobin exceeds the normal of 100, or 300 cc. of plasma for each gram the hemoglobin exceeds the normal of 15 Gm. per hundred cubic centimeters (i. e., if the hemoglobin is 130 per cent or 20 Gm. per hundred cubic centimeters give 1500 cc. of plasma); (4) or 100 cc. of plasma for each 100,000 the red cell count exceeds the normal of 5,000,000 per cubic millimeter (i. e., if the red cell count is 6,500,000 give 1,500 cc. of plasma).

"All formulas based on blood concentration-hematocrit and so on may at times be in serious error. For example, in the first hour or so after the injury the hematocrit may still be normal, plasma loss having just started. In such a case the hematocrit repeated at the third and sixth hours gives a truer picture of the condition. Other patients may be anemic at the time of injury or because of associated wounds. No matter what formula is used, the corresponding dosage for children should be less and is roughly proportionate to the body weight. It should be remembered that formulas dependent on hemoconcentration show only the needs of the patient at the time of testing, not all his requirements during the entire course of the burn.

"(*b*) Formula dependent on the area of the burn: Give 50 cc. of plasma for each per cent of the body surface involved by a deep (blistering) burn during the first twelve hours. Often more plasma must be given later. Burns of the face, groin or buttocks usually lose more plasma than the surface involvement indicates, and more plasma should be given accordingly. Very few persons with less than 10 to 15 per cent of the body surface burned will require plasma transfusions."

Intravenous fluids other than plasma: Harkins et al.[46] say: "In shock, time is extremely important; if plasma or whole blood is not immediately available, give intravenous electrolyte solution (physiologic electrolyte solution or isotonic solution of sodium chloride if the former is not available) rapidly until plasma and whole blood are secured. By the term physiologic electrolyte solution is meant a mixture of 2 parts of normal isotonic (one-sixth molar) (0.9 per cent) sodium chloride solution with 1 part of normal isotonic (one-sixth molar) (1.3 per cent) sodium bicarbonate solution. If sodium bicarbonate solution is not available, sodium lactate normal isotonic (one-sixth molar) (1.75 per cent) solution may be substituted. The final mixture is of the following concentration in round numbers: sodium chloride (one-tenth molar, 0.6 per cent, 100 millomols per liter) and sodium bicarbonate (one twentieth molar, 0.5 per cent, 50 millimols per liter) or, if sodium lactate is used in place of the bicarbonate, sodium lactate (one-twentieth molar, 0.6 per cent, 50 millimols per liter)."[53]

Rosenthal and Tabor say:[54] "A high percentage of animals will survive an

otherwise fatal burn, trauma or hemorrhage if isotonic solutions of sodium salts in amounts equivalent to 10 to 15 per cent of body weight are administered by any route during the first twenty-four hours. The effect of the electrolyte is a function of the sodium ion."

Oral Sodium Lactate.—Fox[55] reports excellent results in 17 cases with oral administration of sodium lactate instead of intravenous administration of plasma. He says: "Large amounts of the chilled isotonic (one sixth molar) 1.75 per cent sodium lactate solution were given by mouth at once and at fifteen minute intervals thereafter on schedule. This solution was prepared by emptying a bottle previously filled with 72 Gm. of sodium lactate syrup into a 4 liter bottle, which was then filled with cold tap water. Sodium lactate syrup varies in composition, frequently containing but 60 to 65 per cent of sodium lactate, in which case 110 Gm. is used. Storage of large quantities of the isotonic solution, which may become sour, was thereby avoided. The burns were rapidly freed of any loose tissue, covered with the local application and bandaged. Blood pressures and repeated samples of blood were taken at frequent intervals during the first twenty-four hours. A careful record of fluid intake is imperative, and an exact schedule is used so that approximately 7 to 10 liters (from 10 to 15 per cent of body weight) of the isotonic sodium lactate are administered within the first twenty-four hours. Any vomiting (which frequently occurs in severe burns) was treated by administration of more fluid. Frequently a small Levine tube was passed through the nose and connected with a drip apparatus, so that the sodium lactate was administered constantly. The urinary output was carefully watched and all urine collected. Fluid administrati[illegible]
daily. When food [illegible]
burned patients by [illegible]

Oxygen: Oxygen is of definite value in severe burns because of the anoxia in the attendant shock.[57] Mutch[58] pointed out that the percentages of alveolar oxygen obtained by different methods of administration are: normal, 15; nasal catheter, 30; oxygen tent, 45–60; B.L.B. (Boothby) mask, 90.

Adrenal Cortical Extract: Rhoads et al.[59] found that "twelve patients with extensive superficial burns who received adrenal cortical extract did not retain plasma given by transfusion any better than did thirteen control patients who received no extract."

Protein: Large amounts of protein may be necessary. (See section on Pathologic Physiology of Burns.)

Toxemia.—The Burns Committee of the National Research Council[60] points out that many deaths occur 48 to 120 hours after the burn and are classified as toxemic in origin. The temperature is elevated, the pulse is rapid, the patient may be drowsy or delirious, vomiting may occur and death may quickly ensue. At autopsy, hepatic necrosis is frequently found as well as changes in [illegible]
serve as a [illegible]
latory collapse. When these signs are present, efforts should be made to increase the urinary output by supplementing the plasma with saline or glucose and maintaining hepatic glycogen by at least 150 Gm. of glucose daily in 5 or 10 per cent glucose solutions intravenously. Sodium chloride should be given so as to maintain a normal blood chloride value.[61] Harkins et al.[46] consider that burn toxemia may be due to one or more of the following conditions: (*a*) inadequate or late treatment of shock; (*b*) "excessive administration of electrolyte solutions with consequent dilution of plasma proteins to the edema level (less than 5 Gm. of protein per hundred cubic centimeters)"; (*c*) infection in burned areas; (*d*) absorption of "*toxic*" protein products from the burned tissues.

Prevention of Infection.—Most deaths after the fourth or fifth day following a severe burn are due to infection. Efforts to control infection will be discussed later.

Systemic Treatment of Infection.—In 1944 Cope[62] said: "Chemotherapy, either by mouth or intravenously, is indicated for all burn patients except those with first degree or other burns of small extent in which the epidermis is intact. It may be withheld in a second degree burn in which it is anticipated that the blisters will not rupture.

"No one or a combination of chemotherapeutic agents attack all the types of organisms known to infect burn wounds. Penicillin promises more than the sulfonamides, since it controls the staphylococcus as well as the organisms susceptible to sulfonamides. It is hoped that this drug will soon be available in greater quantities. In the meantime, sulfadiazine is the drug of choice. In severely burned patients with ruptured epidermis, the drug should be started early by the intravenous injection of 2.5 Gm. of the sodium salt. Subsequent doses should be given either intravenously or by mouth in quantities adequate to maintain a blood level above 6 mg. per hundred cubic centimeters and below 12 mg. per hundred cubic centimeters. It is probable that sodium bicarbonate or citrate should be concomitantly administered by mouth. Such chemotherapy should be continued until the wound is covered with epidermis firm enough to bar the entrance of organisms. If signs of a toxic reaction to sulfadiazine appear, the drug should be promptly omitted."

Later, Cope[63] said: "*Penicillin* is the most effective drug yet available for prophylaxis and treatment. It acts against most of the gram-positive organisms, and when given intravenously or intramuscularly it prevents invasion of the unburned tissue. Given parenterally it is not able to control the growth of organisms in the slough of deep burns. Its instability limits its local use to wounds which can be irrigated at frequent intervals. For a 10 per cent burn, 100,000 Oxford units should be given parenterally per day in divided doses. For burns of greater extent, amounts up to 400,000 units per day may be given. For prophylaxis the drug should be started immediately. In the deep burns of limited extent which are treated with immediate débridement and grafting, prophylactic chemotherapy is optional."[64]

Late Burns.—The chief objective is the prevention and treatment of burn toxemia (which may persist until as late as the third week), anemia and hypoproteinemia. Plasma is seldom necessary after the second day. Amino acids intravenously and whole blood transfusions are required.[65] Harkins and his associates say:

"The immensely important problem of feeding during the often protracted period of infection and anemia cannot be adequately covered in this memorandum. Each case is an individual problem of dietetics and nursing. A full food intake, including calories, vitamins and especially protein, is essential. A few notes may be useful:

"1. Total fluid intake should be sufficient to keep the urine volume 1500 cc. or higher daily. If salt intake has been adequate, body proteins not too much depleted and heart and kidney function competent, this usually means an intake of between 3000 and 4000 cc. daily.

"2. Salt (sodium chloride) intake should be maintained around 10 Gm. daily; a little higher if the burn is extensive with much exudate. Too much salt, however, promotes general tissue edema. Blood carbon dioxide tends to run somewhat low, and some alkaline salt is advisable. Try to keep the urine about neutral to litmus. The physiologic electrolyte solution 1000 to 1500 cc. daily will often be useful during the first five to ten days. Water can be given ad libitum after the fourth day.

"3. Diet should be high in protein, carbohydrate, calories and vitamins. The protein intake should be added to with increasing areas of third degree burns as early as possible after the injury and probably by the end of the first week. Such protein intake should be of the following magnitudes: 5 to 10 per cent body surface burned, 125 Gm. of protein per day; 10 to 20 per cent of body surface burned, 125 to 200 Gm. of protein per day; more than 20 per cent of body surface burned, more than 200 to 300 Gm. of protein per day, provided the patient's gastrointestinal tract can tolerate these large amounts. The corresponding caloric intake should be approximately 3000, 4000 or 5000 calories per day.

"(*a*) Amino acids by mouth, 100 to 200 Gm. per day, are an effective form of protein intake but difficult to tolerate because of the bad taste. Few patients can take them for more than three or four days.

"(*b*) An example of an adequate diet is the diet used by Evans, which is palatable by mouth but also can be given by tube, as follows: 150 Gm. of dehydrated meat powder, 150 Gm. of powdered whole milk, 50 Gm. of corn oil, 150 Gm. of sucrose, 150 Gm. of dextrimaltose, 35 Gm. of chocolate and 1000 cc. of water (plus vitamins, epecially A, B, C and D, and iron).

"(*c*) Adequate vitamins and iron are essential in all unhealed burns. A suggested daily dosage is as follows for burns of 20 per cent area of third degree. Correspondingly smaller doses should be used for less severe burns: vitamin A, 20,000 units; vitamin B: thiamine hydrochloride, 40 mg.; riboflavin, 20 mg.; niacin amide, 50 mg.; vitamin C, 1 Gm.; vitamin D, 2000 units; vitamin K, 1 mg.; ferrous sulfate, 1.5 Gm."

Levenson et al.[66] say: "The nutritional disturbances observed, and especially the increased demand for protein, were found to be directly related to the extent of the third degree burn. High caloric, high vitamin diets with up to 400 grams of protein per day were necessary to maintain adequate nutrition in some patients with very severe burns. When this quantity of food could not be taken or tolerated, gavage and intravenous supplements were given."[67]

General Orders in Cases of Severe Burns.—Harkins et al.[49] advise:

"(*a*) Chart *blood pressure* every 2 hours the first 48 hours and every 8 hours the next 5 days unless below 90 systolic when more frequent readings are necessary.

"(*b*) Chart *temperature, pulse,* and *respiration* every 2 hours.

"(*c*) Chart *daily fluid intake* and *output*, with specific gravity of each urine specimen the first 3 days and later if the daily output is below 1200 cubic centimeters.

"(*d*) Determine the *he* [illegible] the first 12 hours and th [illegible] secondary anemia develo [illegible] determinations are of gre [illegible]

"(*e*) Optional observa [illegible] and blood chemical examination. For the latter, *plasma proteins, icteric index, carbon dioxide combining power, chlorides,* and *plasma potassium* are useful in more or less decreasing importance." In addition to these measures, the following may be added:

(*f*) *Tetanus antitoxin* is given if tetanus infection is possible and if tetanus toxoid has not been previously given.

(*g*) *Sulfonamide drugs.* The recommended dosage of sulfathiazole or sulfanilamide is an initial dose of 2.0 Gm. followed by 1 Gm. every four hours for forty-eight hours and then 1 Gm. every six ho [illegible] below 5 [illegible] by 1 Gm [illegible] hours fo [illegible] days. The blood sulfadiazine content should not be allowed to exceed 10 mg. per 100 cc. The urine should be observed and if anuria develops, the intake of water is pushed, glucose and water being given intravenously if necessary. Sulfanilamide is the best drug for parenteral use (150 cc. of 1 per cent solution of freshly prepared sulfanilamide in normal saline solution subcutaneously every six hours for four to seven days).[58] (See Penicillin.)

(*h*) Burn tent to be kept not warmer than 75° F.[68]

THE LOCAL TREATMENT OF BURNS

General Measures.—The burned area should not be treated until all attendants are properly capped and masked (both nose and mouth covered)

and equipped with sterile gown and gloves. A good light is essential. The operating room or a well-equipped accident room is the best place in which to work. The burn cart described by Siegel and his colleagues[69] is highly useful.

Cleansing the Burned Area.—Initially the burned area is probably sterile, but it is a good culture medium and is readily susceptible to every kind of contamination. When soiling is present, it is advisable to subject the burned area to skillful, gentle and thorough cleansing with soap and water or sterile salt solution. The burned patients from the Cocoanut Grove Disaster in Boston, November, 1942, were treated at the Massachusetts General Hospital with excellent results without cleansing and without débridement. Fine-mesh, boric ointment gauze and pressure dressings were used.[70]

Koch[71] says: "If the open wound has been contaminated before the patient comes to us it is equally logical to attempt to convert it into a clean wound by simple soap and water cleansing, carried out with care to avoid trauma and to avoid further contamination. Concerning the necessity and wisdom of this procedure there has been considerable difference of opinion, owing in large part to the successful results obtained in spite of its omission at the Massachusetts General Hospital after the Cocoanut Grove disaster. There the burned surfaces of the patients were simply covered in the emergency room with sterile towels and shortly afterward with nonadherent gauze and occlusive pressure dressings. One may point out, however, that these cases were not typical of the cases of severe burns that come to the hospital day after day They had had no first aid care; they had undergone a minimum of exposure to external contamination; they reached the hospital within a very brief period after the disaster occurred. Under these circumstances, and in view of the large number of cases demanding attention, no one, I think, would question the wisdom of the method of treatment carried out at that time.

"What happens much more often, certainly with patients admitted to the Cook County Hospital, is that the patient has received extensive, often ill advised, first aid treatment—application of greasy ointment, butter, lard—whatever the corner drug store or home can furnish, and several hours after this application, carried out under voluble mouths and weeping eyes and noses, the patient is admitted to the receiving ward of the hospital.

"After such first aid treatment given three, six, twenty-four hours before the patient is admitted to the hospital, to attempt to convert the injured surface into a clean wound again seems to me simply common sense. Needless to say, one would insist on gentleness, the use only of soft cotton and plain white soap (never scrub brushes or tincture of green soap), irrigation with warm salt solution and the surgical cleanliness routinely employed in a well regulated operating room—masks, sterile gloves, thoughtful care to prevent additional contamination. Loose destroyed tissue which has not been washed away I should always lift away with sterile forceps and scissors. Blisters can be left untouched. Most of them will probably give way under a well applied compression dressing." Rosenberg[72] recommends the cleansing of the burned area with synthetic detergents followed by sterile water irrigations. Various detergent mixtures were used. The principal ingredient was sulfonated petroleum to which was added either sorbitan laurate, dioctyl sodium sulfosuccinate or other agents. Schwartz and Mason[73] investigated 165 active agents useful in cleansing oil-covered skin and burns. They say: "Dioctyl sodium sulfosuccinate in 10 per cent light liquid petrolatum solution had good detergency and high activity as an oil remover in dressing form."

Débridement of the Burn.—Ravdin[74] says: "The débridement of the badly devitalized tissues must be done with the greatest care lest living tissue be further injured, and with the healthiest respect for asepsis. Here indeed is an area which provides a perfect culture medium. The specific local therapy should be designed to discourage bacterial growth and to prevent further contamination. I am sure that extensive débridement under local anesthesia is rarely necessary. It is far better to leave behind small areas of nonviable epidermis and dermis than to remove viable areas from which regeneration

must take place. The extensive scrubbing procedures without doubt cause more shock than the good which they do. The removal of loose skin and the gentle washing of the surface with gauze, good white soap and plenty of sterile salt solution is about all that is required." It is usually desirable to remove the ceiling epithelium of large blisters. In speaking of the small blisters due to hot water bottles, Masson[75] says: "I have been aspirating the fluid from them with a small hypodermic needle. I insert the needle in the skin just a little outside the blister and run it into the blister, well inside the elevated edge of the skin. After removing all of the fluid, the cavity is thoroughly irrigated with a 4 per cent solution of freshly prepared tannic acid and a small amount of this fluid is left inside the cavity. The blister and a small portion of surrounding skin is then painted with merthiolate and a sterile dressing is applied. As a rule, no further treatment is necessary and the patient is free from pain."

Non-Adherent Pressure Dressing Treatment (Koch).—This method is a definite forward step in the treatment of burns and is the most nearly in accord with good surgical principles of any method. The procedure, while simple, is not easy, and it is successful only when meticulous care is observed. By this method what is probably the lowest mortality record has been obtained. The mortality record of severely burned patients on the Children's Surgical Ward of the Cook County Hospital, Chicago, is shown in the accompanying table.

Years	Method of Treatment	No. of Cases	No. of Deaths	% of Mortality
1934–1936	Tannic acid	395	39	10.0
1937 (10 mo.)	Tannic acid and silver nitrate (Hedin)	82	6	7.3
1939	" "	137	8	5.8
1940	" "	164	6	3.65
1941	" "	185	5	2.7

According to Koch and his associates[76] the surgical principles involved in the treatment of burns may be expressed by stating the objects of treatment, namely:

"1. To prevent and combat shock.

"2. To convert the open contaminated wound into a clean wound.

"3. To cover the open wound by the simplest possible dressing that (a) protects it from the constant danger of reinfection; (b) does not fix or destroy any part of the skin or subcutaneous tissue which remains viable when the patient is first seen; (c) provides for drainage of the serum that exudes from the burned suface until it is checked by pressure or the normal process of coagulation; (d) exerts a uniform moderate pressure over the burned area; and (e) can be easily removed if infection develops underneath the dressing or if the burn involves the whole thickness of the skin.

"4. To keep the [illegible]

"5. [illegible]"

The

"To transform an extensive and contaminated raw surface into a surgically clean wound, and without adding further injury and bacterial contamination requires time, patience, gentleness, plenty of soap suds, and continuous irrigation with sterile water of a temperature of 100 degrees F. Obviously the surgeon, his assistants, and the patient must be masked.

The surgeon and his assistant wear sterile gowns and gloves. Every effort is made to carry out the same careful technique that one would carry out in performing an abdominal operation.

. . . ointment which may have been applied over the burned surface can usually b . . . a fat solvent such as benzene is used.* The actual . . . soft sterile cotton, plain white soap, . . . causing unnecessary . . . be lifted away with . . .

"With the injured surface cleansed . . . with a few layers of fine meshed gauze impregnated with pe . . . prepared in strips 3 inches wide and 12 inches long and sterilized in a porcelain . . . vided with a well fitting cover. This dressing does not adhere to the raw surface as does a coagulant crust, it does not fix tissue, and it still permits drainage of serum and exudate into the dressings outside it.

"Over the petrolatum gauze are laid a half dozen layers of flat dry sterile gauze, over this a mass of gauze fluff and over the fluff mechanics' waste or sea sponges so as to provide under the retaining bandage a resilient covering that produces an even pressure over the injured extremity or the burned surface but does not cause constriction.

"The dressing and compressing sponges are held in place preferably with an elastic bandage such as stockinet. This is particularly advantageous if the burn involves the trunk."



Fig. 44.—Koch treatment of burns. Appearance after application of pressure dressing and immobilization with splints. (Allen, H. S., and Koch, S. L.: Surg., Gynec. & Obst. 74: 914, 1942.)



Fig. 45.—*a*, Application of compression dressing over burned face; note swelling of upper lip where compression cannot be applied; *b*, appearance on removal of primary dressing seven days after admission. (Koch, S. L.: J. A. M. A. 125: 612, 1944.)

* Johnston of Detroit has found lard an excellent medium for removing oil and grease. Any lard remaining on the skin can be washed away with soap and water.

Extremities are then splinted and the burned areas placed at rest. This primary dressing is not removed until the twelfth or fourteenth day. Full-thickness burns are later grafted after proper preparation of the skin. Koch advises an ointment containing sulfonamides for patients who come to the surgeon late or who have received prolonged "first-aid" treatment.[77]

The Koch treatment has received strong endorsement from Siler and Reid,[78] who used it in 134 cases, with a mortality of only 3.7 per cent.[79] At the Massachusetts General Hospital the burned patients from the Cocoanut Grove disaster were treated with boric ointment, pressure dressings and splints for extremities. In these cases, cleansing and débridement were omitted.[80] In this connection the work of Pfeiffer et al.[81] is of interest. They conclude that "boric acid, whether applied in the form of an ointment or a saturated solution to extensive wounds, is a cumulative poison. The weak antiseptic value of boric acid suggests that for medicinal use other more active and less potentially harmful therapeutic agents should be employed." Young[82] believes that the Koch treatment is ideal for first and second degree burns but not for third degree burns. (See the section on immediate skin grafting.) Meyer and Gradman[83] found the nonadherent pressure dressings to be superior to the sulfadiazine spray method. Harkins[84] says: "The application of a sterile compression bandage which is not changed until the tenth to the fourteenth day after the burn is at the present writing the best definitive local management of thermal burns."[85]

Aldrich Triple Dye Treatment.—In 1937 Aldrich[86] advocated a combination of acriviolet (a mixture of acriflavine and gentian violet) and brilliant green in the treatment of burns. He said that this combination is "the most powerful antiseptic against gram-positive bacteria that will not injure living cells"; it also acts strongly against gram-negative organisms.

The triple aniline dye of Aldrich[87] is prepared as follows, the parts being given by weight:

Crystal violet (hexamethyl pararosaniline hydrochloride)	1.5
[illegible]	0.75
[illegible]ride)	1.0

In practice, 6.5 Gm. of this mixture is dissolved in 250 cc. of water and the resulting solution is applied to the burned surface or surfaces with a suitable vaporizer, atomizer, spray, or the like.

Only loose shreds of the skin blebs and oily substances are removed from the burned area. The 2 per cent [illegible]
as eac [illegible]
patient [illegible]
about [illegible]
eschars [illegible] infection. Each infected eschar must be removed and the areas then resprayed. The entire procedure is repeated each day until new skin begins to form, or the granulating area is ready for skin grafting. In burns that can be kept exposed to air the dry eschar [illegible]

"Burns i[illegible]
moist and t[illegible]

"At the [illegible]

to spread, or when the granulation tissue will accept a skin graft, the aniline treatment should be discontinued. The period of aniline therapy depends entirely on the depth of the burns and the individual's own recuperative power; the average time is about one month."

After the separation of the eschar, Aldrich says that "epithelial stimulation as a third and final phase in the treatment of burns definitely occurs under the high A and D vitamin potency of cod liver oil, preferably as a 70% concentrate in an ointment, consisting of 30% wax and small amounts of zinc oxide, benzoin, and phenol, which brings about a slight drying and antiseptic action. This ointment, spread easily on gauze, is changed twice a day in hospitalized cases, once a day otherwise, until healing is complete."

Hull[88] prefers the Aldrich dye to other eschar producing agents. He says:

"The mixture does not deteriorate over a long period of time. In comparison with tannic acid, it is more expensive and more soiling, and the eschar takes longer to dry. On the other hand, the dye is more antiseptic and forms a thinner and more pliable eschar, under which infection is easier to detect. The dye can readily be removed from the person of the nurses or the operators with aromatic spirit of ammonia.

"The technic employed is much like that of tannic acid application. After thorough gentle cleansing of the involved areas, the dye mixture is applied by sterile cotton pledgets six to eight times at twenty minute intervals. The patient is then transferred to a sterile bed. A cradle is placed over the bed, and heat slightly above 40° C. is maintained by electric bulbs. The drying of the eschar at times takes as long as twelve to eighteen hours, and every effort is made to keep the patient from contamination during this period. The pain is relieved after the first or second coating as with any other agent. The resultant eschar is deep purplish black with a gold-green sheen."

The triple dye method is also praised by Wakeley[89] and Devine.[90]

The Slow Tanning (Tannic Acid) Treatment.—A brief description of the slow tanning method of treatment is given herewith because of the historical importance of this method and its occasional usefulness.

In 1944 Lee and Rhoads[91] said: "Our present knowledge indicates that the tannic acid treatment relieves pain well, helps prevent infection in second degree burns and perhaps delays the development of infection in the deeper burns until danger from shock and toxemia have passed. It does not prevent toxemia, and if it is absorbed in sufficient quantity it is capable of producing liver damage. On the other hand there is as yet no substantial evidence that it has increased the mortality of burns in man. It decreased the loss of plasma-like fluid from the surface of second degree burns, but there is no conclusive evidence that it has reduced the loss of plasma from the circulation into the tissues.

"Numerous statistics in the literature indicate that its use was followed by a decrease in mortality, and we believe that it has saved many lives. Now, however, that invasive infection is so well controlled by chemotherapeutic agents it seems likely that the tannic acid method will be superseded more and more by other methods, many of which are similar to the very methods it displaced before the days of the sulfonamides."[92]

In 1925 Davidson[93] published his epoch-making contribution to the therapy of burns. This worker, in searching for a chemical which would fix the toxic substances in the burned tissue, hit upon tannic acid. His original method was, at the earliest possible moment, to cover the burned area with gauze saturated in a 2.5 per cent freshly prepared aqueous solution of tannic acid. The gauze was kept moist with this solution for twenty-four hours or more, until the burned skin was thoroughly tanned.

In 1926, Beck and Powers[94] introduced the method of applying the tannic acid by means of a spray. These authors advised that the burn be covered with a fine spray every half hour until the surface becomes brown or black. Davidson,[95] in 1929, wrote that he had [illegible]

coagulation in two to three hours.

There is no question but that the treatment of burns by the tannic acid method greatly [illegible]

Whether the tanning method does this by sealing off the damaged tissues and preventing fluid loss or by precipitating and diminishing the absorption of toxic products is still uncer-

tain. But the fact remains that during this period the mortality has been markedly diminished."

Experimental work indicates, however, that the tannic acid treatment causes unnecessary destruction of viable tissues. More disturbing is the *relationship of tannic acid to liver necrosis.* Erb and his associates[98] studied the postmortem findings in sixty-one fatal cases of burns. Of the forty-one cases in which tannic acid treatment was used, twenty-five (61 per cent) showed liver necrosis. Of twenty-seven cases in which tannic acid was used and death occurred in three to nineteen days, only three failed to show liver necrosis. *No case of liver necrosis occurred in the 20 "untanned cases."*

Wells and his colleagues[99] report four cases in which death occurred following extensive burns treated by slow tanning. In each case there was a central lobular liver necrosis as a prominent lesion or as the sole cause of death. These authors produced liver damage in rats by the injection of 1.5 cc. of 5 or 10 per cent tannic acid solution. They conclude: "In patients with severe burns treated with a tannic acid solution, tannic acid jelly or tannic acid and silver nitrate solutions, tannic acid poisoning resulting in a hepatitis may become clinically and chemically demonstrable within thirty-six hours and may result in death from a specific central necrosis of the liver in from eighty to one hundred and thirty hours or more. The specific central necrosis of the liver due to tannic acid poisoning should be distinguished from the cause or causes of the so-called 'toxemias' of burns and scalds."



Fig. 46.—Tannic acid treatment of burns, showing condition of the burned area after treatment with tannic acid. (Children's Memorial Hospital, Chicago. Courtesy of Dr. A. H. Montgomery.)

Allen and Koch[100] reduced the 10 per cent mortality with tannic acid treatment to 2.7 per cent with non-adherent pressure dressings. Wakeley and McIndoe[101] emphasize that "the tanning of third degree burns of the hands hinders the already impaired circulation and leads to edema, which by compressing the vessels to the fingers causes necrosis. When healing finally occurs, the mutilated fingers are dragged backwards by scar tissue and a useless claw results. The results of coagulation treatment of the face may be even more distressing. The eyelids, fixed by horny tan, cannot be removed for a matter of days or weeks. Thus in the early stages a damaged eye may be out of reach of treatment while in the later stages contractures and extropion leave the cornea exposed to injury and infection which may eventually destroy sight."

McIndoe believes that no third degree burn should be treated with tannic acid coagulation. Cannon and Cope,[102] in an effort to test the various agents recommended for the [illegible]

[illegible] the triple dyes, and triethanolamine solutions, all have been found to delay epithelial healing as compared with the control boric acid ointment." Hirshfeld and his colleagues[103] carried out similar experiments and concluded that "donor sites heal more quickly with less discomfort when treated by vaseline gauze than when treated by tannic acid." Robinson and Graessle[104] found tannic acid toxic in experimental animals.

The tannic acid method will not work in the presence of previously applied ointments. When a patient with extensive burns arrives at the hospital covered with an ointment, this

should be removed after the administration of a generous dose of morphine or even a general anesthetic. Xylene is helpful in removing ointments.

All clothing and dressing of any kind are removed from the patient, who is placed in bed, on sterile sheets, under a cradle tent. An electric light bulb of proper size is placed inside the tent to insure proper warmth (75° to 85° F.) and dryness. The spraying is continued until the burned area is brown and dry (Fig. 46). This coagulation is undisturbed for twelve or more days. If infection supervenes, it is treated by tepid saline irrigations and drainage from beneath the crusts. Wet boric dressings should not be used. "It has been found . . . that if wet dressings of boric acid are used, a rapid toxemia arises that is frequently fatal."[105]

The coagulated crusts should not be disturbed until they separate. Beck and Powers[94] recommend softening the crust with petrolatum to facilitate its detachment when the proper time comes.

No tannic acid preparation should be used on the hands or face. The British Emergency Medical Services[106] say:

"Further experience in the treatment of burns has proved conclusively that the use of tannic acid on the hands, especially the fingers, is followed by disastrous crippling in burns of the second and third degree. Instructions in E.M.S./Gen./325 are to be amended accordingly and treatment with saline packs or arm baths will be substituted.

"In burns of the hands and/or fingers of the second and third degree, initial treatment should be confined to saline compresses or intermittent saline baths for at least one week, or until the œdema has subsided and sepsis has been controlled.

"If coagulation methods are then deemed advisable, the hands and fingers should be treated with gentian violet or triple dye, reinforced when necessary with a thin layer of sterile gauze. This dressing should be applied so that only a partial casing is produced—for example on the back and front, but not the sides, of the fingers. Under no circumstances should a complete casing be applied." Rubber tissue may be used to keep the fingers separated.

The availability of the tannic acid method is evidenced by Shen's paper in the *Chinese Medical Journal.*[107] Shen found an infusion of tea to be nearly as effective as the tannic acid solution and gives the following directions for its preparation. One gram of tea leaves in 100 cc. of boiling water is considered as a 1 per cent infusion. The infusion, to be effective for protein precipitation, must be 8 per cent. A fifteen minute 8 per cent infusion is prepared and sterilized by boiling. This tea is dark red and bitter to taste.

Tannic Acid-Silver Nitrate Treatment (Rapid Tanning Method).—Bettman[108] has found tannic acid plus silver nitrate superior to tannic acid alone in the treatment of burns. The chief advantage is the rapidity of action. Bettman[109] says: "Under the tannic acid and silver nitrate treatment with drying in a series of 744 consecutive burns, twenty-three have been lost, or 3.1 per cent. Surely a treatment which gives such a low death rate deserves a high place in the treatment of burns."

The National Research Council[44] describes the tannic acid-silver nitrate method of rapid tanning as follows:

"Two solutions are to be employed, (1) a freshly prepared 10 per cent solution of tannic acid and (2) a 10 per cent solution of silver nitrate. Two spray guns are to be available, one [illegible]

early grafting."[110] When infection beneath the crust is suspected because of the presence of fever, small windows are cut in the crust. If pus is found, the crust is removed. The surface is irrigated with warm saline solution, and a light frosting of sulfanilamide is applied Saline or ointment dressings may then be used.[111]

Miscellaneous Local Treatments of Burns.—*Sulfathiazole Ointment (Dragstedt).*—Fine-mesh (40 x 44) gauze impregnated with 20 per cent sulfathiazole in a mixture of oxycholesterol, 5 per cent, and petrolatum, 95 per cent, has been used to advantage in burns. It is helpful in infections due to staphylococcic, streptococcic and colon bacilli. Although as much as about 100 Gm. of sulfathiazole was used daily on the burned area, the blood sulfathiazole content did not exceed 1.5 mg. per 100 cc.[112] In Dragstedt's clinic at the University of Chicago the sulfathiazole emulsion ointment has been used in 60 cases of burns. The present formula for the ointment is as follows:

Oil phase	
Petrolatum	48 cc.
Arlacel C	2 cc.
Aqueous phase	
Sulfathiazole	5 Gm.
Tween 80	½ cc.
Water q.sa. d.	100 cc.

In discussing this preparation, Jenkins et al.[113] say: "Sulfathiazole emulsion ointment was found to be very satisfactory in the treatment of burns and would appear to be especially suited to the first aid type of burn treatment when cleansing procedures may not be feasible because:

"1. There is sufficient liberation of sulfathiazole from the ointment to have at least some bacteriostatic effect which is not obtained by grease dressings alone.

"2. The liberation of sulfathiazole is controlled in this ointment preparation to the extent that overwhelming systemic absorption of the sulfathiazole does not occur. It is, therefore, feasible to treat burn patients with this ointment under conditions where it may not be possible to follow the blood sulfonamide level by laboratory tests.

"3. The liberation of sulfathiazole from the emulsion ointment is continued for a period of a week or more and thus permits a continuous bacteriostatic effect.

"4. The sulfathiazole emulsion ointment has an analgesic effect on the burned surface which minimizes the extent of sedation required and thus keeps the patient in a relatively more ambulatory condition.

"5. The emulsion ointment can be removed from burned areas with less difficulty than can ordinary grease dressings if it should be desirable to change the dressings.

"6. The emulsion type ointment may be easily prepared from sterile ingredients when it is needed with a simple salad dressing mixer."

Sulfathiazole Emulsion, 5 per cent (Montreal General Hospital).—This is a liquid emulsion whose formula[114] is: 5 per cent of finely powdered sulfathiazole, 2 per cent of triethanolamine, 24 per cent of water, 5 per cent of beeswax and 64 per cent of liquid petrolatum.[115] The sulfathiazole emulsion is applied to the burned area by means of a thick pressure-type dressing. Wide-mesh (1–2 mm.) gauze is used next to the burned area, and over this a liberal coating of the sulfathiazole emulsion is applied. The Montreal General Hospital group[116] have not discarded the tannic acid-silver nitrate method for large areas "when life saving is involved."

Sulfadiazine Spray Method (Pickrell).—At the Johns Hopkins Hospital 115 patients were treated by this method with only two instances of infection.

The burned areas are not washed but are sprayed by means of an atomizer with a mixture of 3 per cent sulfadiazine in 8 per cent triethanolamine. Blebs and loose tissue are then débrided. The patient is placed on a sterile sheet under a cradle, the temperature not to exceed 90° F.[117]

This method was used in fifty cases by Adams and Crawford.[118] There were ten deaths, in two of which the burns were of minor degree.[119] Rothman and his associates[120] used 2.5 per cent sulfadiazine in 8 per cent triethanolamine for thirty-two patients, with two deaths.

Chemotherapeutic Membranes.—Pickrell[121] used a preformed film on the burned surface. The film is made in the following manner:

"An emulsion is prepared containing 3 per cent of sulfadiazine or sulfanilamide, 2.5 per cent of methyl cellulose, 3 per cent of triethanolamine and 0.5 per cent of sorbitol with 50 per cent alcohol or acetone added to make 100 cc The resulting emulsion is sprayed with a pressure gun or paint spray on a smooth horizontal glass surface. This is allowed to dry; if acetone is used, drying is extremely rapid, but if 50 per cent alcohol is used, several hours at 75 C. are required before the film can be removed in a single sheet. The films are stable and can be sterilized by dry heat. Composition studies reveal that the film ordinarily contains 35 to 50 per cent of the sulfonamide compound." The author has used these sulfonamide films for fifty patients with burns for whom a surgical detergent was used to clean the burned surface and the surrounding skin if it was grossly contaminated. The area was then washed with saline solution, sulfadiazine or azochloramid solution. While the surface was still moist, the sulfonamide film was placed to overlap the burned surface. A smooth, firm pressure dressing of gauze was then applied. This film remains in place for three to five days, at which time epithelization will be taking place in second degree burns. Since the film is translucent, the injured area can be inspected without removing the film. In third degree burns and in exudate lesions the film may be renewed as desired Sulfadiazine films appeared to offer greater local protection against infection than did the sulfanilamide films.

Andrus and his colleagues[122] have used hydrated films prepared from methyl cellulose in twenty cases of burns. Incorporated in these films is sulfanilamide, 10 per cent, and a buffer to make the *p*H slightly alkaline. In some of the films, azochloramid was also added. The films are transparent and may be used in one to three layers or mounted on gauze.[123] Andrus and Dingwall[124] report favorable experience in 57 cases with this method.[125]

Cod Liver Oil (Löhr).—Löhr[126] used cod liver oil in the treatment of 1000 extensive first, second and third degree burns and believes that this agent is remarkably effective in controlling the secondary infection, that a rapid cleansing of the wound follows its application and that epithelization is stimulated to a degree not seen in any other form of treatment. Hardin,[127] on the basis of his experience with twenty-two cases of major burns averaging 14.8 per cent of the body surface and in thirty-nine minor burns, believes that cod liver oil* is superior to other methods of treatment.[128]

Bunyan Envelop (Bunyan-Stannard Bag)—Bunyan[129] has treated 200 cases with his watertight coated-silk envelop with inlets and outlets which make it possible to irrigate any part of the body by inserting a glass nozzle into one of the openings. "When the skin is broken, necrotic tissue should be cut away under a stream of electrolyte sodium hypochlorite, bathed for ten minutes in a 10 per cent solution, covered with a sheet of the special coated silk and sealed at the edges After a suitable envelop is applied, it is inflated with oxygen, and the inlets are sealed. Routine irrigation begins the next day: 5 per cent electrolyte sodium hypochlorite is employed at 100° F. and is run through the envelop over the affected area or areas for twenty minutes. This procedure is carried out three times a day. After irrigation and drainage for half an hour, the envelop is inflated with oxygen."[130]

* See also Thiessen, N. W., and Steinreich, O. S.: Mil. Surgeon 91: 208, 1942 (10 per cent sulfathiazole added to 10 per cent cod liver oil ointment).

Sulfonamides.—Rhoads and his colleagues[131] have employed powdered sulfanilamide, sulfathiazole and sulfadiazine as a primary and as a secondary dressing after other forms of treatment. They believe that this method has reduced the need of skin grafting. The drugs are freely absorbed from the burned surface and may cause toxic effects. Hooker and Lam[132] point out the danger of overdosage of the sulfonamides if used on large areas.[133] Evans et al.[134] have made studies which "indicate that the absorption of sulfonamides from the burn surface is limited when oil base ointments are employed. In contrast, when a water-dispersible base is used, toxic blood levels of the drug may occur."

Paraffin Wax—Open Air Treatment (Pendleton).—Pendleton[135] uses the following formula:

Paraffin wax.. 670 Gm.
  Household wax. Melting point about 125 F. This softens the skin.
  For first aid ointment reduced to only 20 Gm. rather than 670 Gm.
Petrolatum.. 250 Gm.
Liquid petrolatum (heavy).................................. 150 cc.
Cod liver oil [illegible] 50 cc.
[illegible] 50 Gm
[illegible]
  effective antiseptic (before sulfanilamide).
Menthol.. 1 Gm.
Camphor.. 1 Gm.
  The e relieve any itching or burning sensations.
Oil of eucalyptus.................................. ...... 1 cc.
  Used as a deodorant.

He says: "Without cleansing or débridement of the fresh burn, the paraffin wax formula is sprayed on all burned areas immediately, sometimes preceded by frosting of the burned area with sulfanilamide powder. The wax and petrolatum are mélted on a water bath; then the other materials are stirred in. While still melted, pour the mixture into insectide spray 'guns' and allow to cool (melting point 117 F.)." The burn is sprayed frequently and washed off with tap water from time to time.

Plaster Casts.—Plaster casts have been advocated by Glenn and his colleagues[136] for use in the treatment of burns. Levenson and Lund[137] have had very satisfactory results with this method in 22 cases.[138]

Other Agents.—Among the large number of agents recommended in the treatment of burns,[139] the following may be mentioned: Azochloramid,[140] foille,[141] closed plaster casts,[142] zinc peroxide (in hemorrhage from infected burns),[143] tulle gras,[144] englamide (glycerin-sulfonamide paste),[145] wet dressings (Burow's solution, part 1, in 50 parts of normal saline solution),[146] sulfadiazine-tannic acid jelly (Lederle) and saline-glycerin-acetic acid solution.[147] Picric acid ointments are to be condemned because they frequently cause dermatitis.[148] Hirshfeld et al.[149] are unconvinced that "Bio-Dyne" ointment has any advantages over petrolatum gauze for the treatment of burns.

Skin Grafting in Burns (See Section on Skin Grafting).—The Committee on Burns of the National Research Council says:

"Almost invariably the error is made of waiting too long before grafting skin and of [illegible] spontaneously. If this rule seems too radical, exceptions or modifications should be made only after careful consideration."

Immediate Skin Grafting.—Young[150] recommends the immediate excision of all areas of obvious third degree burns and the suture over these areas of split-thickness skin grafts (about 0.010 inch thick) cut with a dermatome. He reports one very successful case.[151]

Care of the Granulating Surface.—The patient's general condition must be improved with a diet high in sulfur (eggs), vitamin C and proteins. The hemoglobin value must be at least 70 per cent.[60] James Barrett Brown and his associate[152] say:

"Early grafting of burns is the ideal procedure and most of them can be cleaned up, sloughs separated and the patient generally ready for operation in 20 to 30 days. This requires open surgical drainage, débridement, and general supportive measures for the patient. Chemotherapy locally, and generally if infection is present, soap and water cleans-

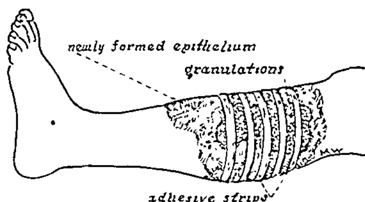


Fig. 47.—Method of accelerating epithelization by bridging granulation tissue with adhesive strips

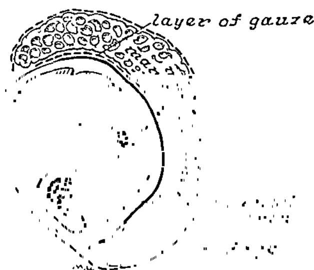


Fig. 48.—The use of a moist marine sponge to effect pressure upon the granulating area left by a burn

[illegible] standard

[illegible] other sealing

[illegible] " Saltonstall

[illegible] ridement.[154]

Gurd and Gerrie[155] say: "Exuberant granulation tissue is an abortive attempt at wound

healing that has been unsatisfied by epithelial covering at the appropriate time. It decreases the certainty of graft take and increases subgraft scar. Skin grafting of burned surfaces is therefore preferable before granulations become obvious. Exuberant granulations are the result of prolonged wound treatment and are no serious contraindication to skin grafting provided they are removed. It is preferable to remove exuberant granulations and graft rather than to give them prolonged treatment to render them less exuberant before grafting. The removal is done by a scraping motion with sharp scalpel rather than a slicing procedure. This provides a more even base with less bleeding. They are taken down to the firm yellow base from which they spring. The scalpel is preferable to a curet. Bleeding is, as a rule, easily controlled by the application of hot packs and the prompt application of the skin graft, which itself seems to have a pronounced hemostatic effect. Sutures or ties are seldom necessary to control hemorrhage."

Saline baths and compresses, the Bunyan envelop with 2.5 per cent sodium hypochlorite solution irrigations, cod liver oil ointment, sulfonamide ointments, petrolatum gauze and 3 per cent xeroform ointment gauze are also useful in the preparation of the granulating surface.[156] Pyruvic acid has been found helpful in the removal of slough under experimental conditions.[157]

Bettman[158] highly recommends the following preparation in the treatment of the granulating surfaces of healing burns:

"The formula, which has been called oxyquinoline sulfate scarlet R ointment is as follows:

	Gm. or cc.	
℞ Oxyquinoline sulfate	0.6	gr. x
Chlorbutanol (chloretone)	2.4	gr. xl
Liquid petrolatum	4.0	ʒ j
Scarlet R ointment, 5 per cent	120 0	℥ iv

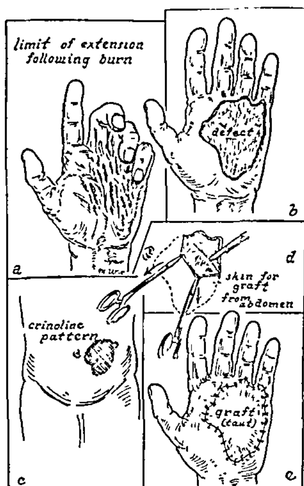
"When 10 per cent scarlet R ointment is used, take 2 ounces and petrolatum, 2 ounces. The oxyquinoline sulfate and the chlorbutanol are ground separately into fine powders and then mixed separately with portions of the liquid petrolatum. All the ingredients are then made into a red ointment. The finished ointment is heated until fluid, and rolled gauze bandages, 32 by 44 mesh, or coarser, are immersed in the hot ointment until the entire bandage is thoroughly impregnated, until all bubbling has ceased. When cool, it is ready for use. The finished product has been called oxyquinoline sulfate scarlet R gauze."*

Small Deep Grafts ("Pinch Grafts," Reverdin Grafts).—These grafts are the simplest to cut and to apply. They often succeed wholly or in part when some infection is present, although success is greater when the granulating area is free from infection.[159] (See section on Skin Grafting.)

Thick-Split Grafts, Dermatome Grafts, Full-Thickness Grafts, Z Flaps and Pedicle Flaps.—Gurd and Gerrie[160] say: "The Padgett dermatome has taken some of the 'ifs' out of skin grafting and has many advantages over the older knife and razor methods. It is not fool proof, and one must become familiar with the vagaries of knife, cement and drum. If used with care and understanding, even sheets of skin may be cut from almost any part of the body. It has the advantage of calibrated adjustment, and even thickness may be cut from 0.006 of an inch to full thickness of the skin." These authors prefer grafts between 0.008 and 0.016 inch in thickness, which is about half skin depth. Thin grafts are more certain of take than thick ones. Gurd and Gerrie add: "The dermatome is set up on a separate table and, if possible, the wound preparation and skin grafting are kept as separate procedures. The skin is sliced off to the desired amounts and depths. The thinner grafts are usually

* A case of marked sensitivity to scarlet red ointment has been reported by McEvitt, W. G.: Plastic & Reconstruc. Surg. 1: 193, 1946.

transferred to sheets of our wide mesh lace buttered with sulfathiazole emulsion. The skin adheres to the lace, so that it is more easily handled, since the surfaces which are at least partially covered by cement are prevented from sticking together. The lace and skin are sewn in; the lace helps to 'fix' or 'snub' the skin into position. If thicker skin is used, it is sewn in alone without the intervention of the lace, as it contains too much elastic tissue and curls away from, and will not adhere to, the lace.



[illegible] under tension; *e*, graft sutured over the palmar defect. (Koch, S. L., and Kanavel, A. B.: J. A. M. A. 92: 277, 1929.)

"The amount of skin transferable at one operation is limited only by the amount of time available and the patient's condition. In extensive burns it is wise to have two teams at work, one cutting the skin and the other sewing it in place. In this way maximum areas of skin may be transferred at one operation. Grafted and ungrafted areas are dressed together as was the original burn and left for ten to fourteen days before another intervention. If, at this next dressing, skin coverage is complete or nearly so, sutures are removed and the graft and donor sites exposed to the air and given petrolatum or olive oil massage."[161] (See the section on skin grafting.)[162]

Chemical Burns.—Davidson[63] has made an experimental study of the treatment of *acid and alkali burns.* He concluded:

in all *chemical burns.* Where white phosphorus has come into contact with the skin it is of extreme importance to keep the area dry and away from water. Some authors even recommend covering the area with petrolatum to protect it from contact with sweat. The method of choice, however, is to paint the phosphorus burned area with a 1 per cent solution of copper sulfate to form a coating over the phosphorus and then lavage the area with physiologic salt solution. Phosphorus burns will be most commonly observed in military practice from shells, smoke screens, etc.

"Other burns encountered in military practice are those produced by war gases. Lewisite burns may be treated with a 2 to 5 per cent solution of sodium hydroxide followed by alcohol or a ferric hydrate paste in the case of vapor burns. Mustard gas burns may be treated with sodium hypochlorite, benzene, ether, or alcohol. Methyl difluorarsine and methyl dichlorarsine burns are treated by 2 to 5 per cent solution of sodium hydroxide and then soap and water.



Fig. 50.—Scar following burn of the hand.

"Manifold types of chemical burns occur in industry. A few of these warrant consideration. Chromium burns occur in workers in dye materials, photo-engraving, steel, and leather tanning. Such burns are treated with the application of ammonium polysulfide. Cyanide burns are also preferably treated with the polysulfide of ammonium or with a concentrated solution of potassium permanganate. Tar burns constitute a problem in the removal of the noxious agent. This can best be done by using trichlorethylene as a solvent. It must be remembered, however, that it is a powerful general anesthetic, and the room in which it is used should, therefore, be well ventilated. Caustic potash and caustic soda burns are treated with acetic acid." Beck ... ohol.

... ncludes:

... by a thorough wash with warm sodium bicarbonate solution (roughly 2 tablespoons to a pint [500 cc.] of water). Any obvious particles of phosphorus disclosed ... be picked off with ... copper sulfate an... affected area sho... solution for a prolonged period. The duration of this soaking depends on the size and depth of the burn—small burns half ...

... begins (seven to ten days) boroseptic ointment provides a satisfactory dressing, and its use can be continued until the scar produced is sound. Tannic acid and other coagu-

ants do not give satisfactory results. The disadvantage of acriflavine emulsion is that individual, local and generalized cutaneous eruptions may occur, but a daily inspection will detect them, when boroseptic ointment should be substituted. With this treatment results are obtained which are comparable to those of burns caused by caustic soda and sulfuric acid. Healing is slower and scars are thinner in burns caused by phosphorus."[166]

In regard to *magnesium burns*, Wilson[167] says:

"*Magnesium burns are often very small and form ulcers if not treated at once; over a* period of several weeks they enlarge to several times the size of the original burn. The floor of the ulcer is made up of several reddish-brown granulomatous tubercles. McCord *et al.* advised wide excision of the magnesium particles if they should become accidentally embedded in the tissues as metallic magnesium interferes with the normal physiology of the body cells and thereby prevents normal repair processes. No chemical neutralizing agent could be found for the deleterious effects of magnesium in the tissues. The area of the burn is anesthetized with 2 per cent novocaine and the burned tissue is scraped away until normal tissue is obtained. With this treatment, light metal burns will heal as quickly as burns caused by the heavy metals. Untreated magnesium burns result in chronic slow-healing lesions. Accidental burns by incendiary bombs should be treated in the same manner."

For *cement burns*, Meherin and Schomaker[168] have published their recommendations.

Chemical Burns of the Eye.—In all cases of chemical burns of the eye, dilution with tap water should be carried out immediate y.

In *lime burns of the eye* the immediate treatment is dilution with tap water. Then the gross particles should be removed by manipulation and a douche of 3 per cent sodium bicarbonate or boric acid solution. Rutherford[169] advises irrigations with freshly prepared 2 per cent aqueous solutions of neutral ammonium tartrate or ammonium chloride. The solution of tartrate should gradually be increased in strength up to 20 per cent if tolerated. Olive oil may then be instilled. For the resulting corneal opacity, the eye should be cocainized and washed with a freshly prepared 10 per cent solution of neutral ammonium tartrate.

Hubbard[170] believes an acid burn of the eye shou'd be irrigated with water only and not with a weak alkali but that an alkali burn should be irrigated with a weak acid.[171]

Allen[172] says: "The use of tear gas is increasing, consequently we must be prepared to care for such cases. Dr. Wm. D. McNally recommends, after considerable experience, first —large quantities of tap water, followed by 0.4 per cent sod. sulphite, in glycerine 75 per cent and water 25 per cent. This should be used immediately and frequently in the eyes, and if severe burns have occurred the fornices must be probed to keep adhesions from forming between the lids and eyeball. On the face 4 per cent sod. sulphite in 50 per cent alcohol is more efficacious.

"For refrigerating gas (SO^2) burns, sod. bicarb. 0.4 per cent in glycerine 75 per cent and water 25 per cent is found efficacious. It also should be preceded by thorough irrigation with quantities of water."

For mustard gas injuries of the eye, Hughes[173] says:

"By opening the swollen lids the patient can be assured that he is not blind. Local anesthetics should be avoided, however; if necessary for examination, 1 drop of a 5 per cent isotonic solution of pontocaine may be instilled. The eye should be irrigated for two minutes with a 1.5 per cent solution of sodium bicarbonate, isotonic solution of sodium chloride, a 2 per cent solution of boric acid or a 0.5 per cent solution of dichloramine-T in chlorinated petrolatum. For patients with corneal involvement or extreme photophobia a 1 per cent atropine solution or ointment should be instilled every day until the symptoms subside. When the involvement is severe, drops or an ointment of liquid petrolatum, cod liver oil with added sodium bicarbonate and dextrose or acriflavine in castor *oil 1:15,000 should* be instilled three times a day. Dark glasses or a brown eye shade should be used, but only for a short time. Bandages or eye pads should be avoided. Finally a 10 per cent mild protein

silver solution, followed by irrigation with boric acid solution, should be instilled three times a day. A 0.25 per cent solution of zinc sulfate with epinephrine should be used during convalescence. As yet no satisfactory neutralizing agent for mustard gas that is tolerated by the eye is available; therefore as soon as the faint, transitory mustard or garlic odor is detected or the presence of mustard gas is suspected the gas mask should be put on."

PROTECTION FROM SUNBURN

Luckiesh et al.[174] made a study of the most effective substances for sunburn prophylaxis and reported as follows: "*Dark red vet. petrolatum* (Standard Oil Company of New Jersey) was found to be quite opaque to erythemal energy. It likewise served as a complete protection to the skin in an exposure equivalent to twenty hours of the strongest sunlight in Cleveland measured during a four year period. This product in itself is recommended for the protection *of aviators marooned on life rafts or in the desert following airplane crashes.* The compound is not irritating and adheres tenaciously to the skin. *Phenyl salicylate* (salol) was also found to be an excellent protection from ultraviolet radiation when put up in a 10 per cent cream. Experiments have also shown it to be nontoxic. It is further felt that a 10 per cent phenyl salicylate incorporated in the dark red vet. petrolatum be also tried as a suitable agent for protection of marooned aviators."[175]

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CHAPTER V

FOREIGN BODIES

A GREAT *variety* of foreign bodies has been encountered in the human body. A large group includes all types of missiles; bullets, fragments of shrapnes, cartridge wadding and BB shot are common types. Another group comprisel needles, portions of needles, pieces of glass, splinters, etc. (Fig. 51). A very large group of foreign bodies is composed of those which find their entrance into the body through the orifices. The eye, nose, mouth (including both the esophagus and the trachea), urethra and anus are included in this group.

"Compact and insoluble foreign bodies are shut in by new-formed tissue, which is slowly transformed into a connective-tissue capsule, gradually shutting the foreign body off from contiguity with the organism."[1] Foreign bodies which are not infected may remain in the tissue indefinitely without causing symptoms. Paschal[2] reports the case of an Indian who for sixty-one years carried an encysted arrowhead in the thoracic wall between the second



Fig. 51.—Sewing needle embedded in the sole of the foot.

and third ribs. Another of his patients carried an arrowhead for twenty years. The first eight years were symptomless, but then the foreign body became infected, and for the remaining twelve years the patient suffered from abscesses and sinuses. In a third case reported by this writer the patient carried a sizeable piece of glass in his thigh for eight years without symptoms until a blow upon the thigh made it painful. Kummer's[3] case is of interest. He removed a cyst the size of a pea formed about a fragment of a needle that had been embedded in a finger for three years. The cyst was pear shaped. The stem of the pear was formed by the needle closely surrounded by tissue. The other end projected into the bulbous cavity.

As far back as 1797 there was described a case in which a thorn was removed from a

cessation of the heart beat when the bullet was palpated. The heart resumed its beating, and twenty-four years later the man was well.[8]

Norris and Reich[9] believe that metallic foreign bodies cause very little trouble in the tissues and that their removal is indicated when they produce mechanical irritation or pressure or when they are located in an infected field. They say: "When foreign bodies cause mechanical irritation in the pleura or are adjacent to nerves, as for instance, the [illegible] the sole of the foot, the palm of the hand, the back, the buttocks. . . ." I know of a case in which a steel fragment was embedded in the wall of the brachial artery. Upon its removal a copious hemorrhage ensued until a tourniquet was applied.

All types of needles have been found in the body (Figs. 51, 52). The common sewing needles, broken off fragments of sewing machine needles and portions of surgical and hypodermic needles are the commoner types. There is no question that needles and other sharp-pointed or thin foreign bodies will move about in the body. A woman presented herself to the writer at the New York Hospital with a needle in the soft tissues of the neck, which was easily removed under local anesthesia. The chief point of interest in this case was that she had absolutely no recollection of the time when the needle entered the body. Needles have worked their way along muscle planes to sites remote from their point of entry.

Numerous instances have been recorded of *migration of foreign bodies.* Foreign bodies in the veins may migrate to the heart or lungs (Warthen[10]). In the case reported by Shapiro,[11] a needle used for giving intravenous injections became separated from the hub and entered the blood stream. It was later found outside the heart in the prepericordial fat above the left dome of the diaphragm. It remained in this position without causing trouble. Siegling[12] reports on a case in which a small fragment of a cold chisel entered a vein in the cubital fossa and before it could be removed had migrated through the heart and lodged in the lower lobe of the right lung. In the case reported by Laird[13] a bullet entered the chest and was removed from the femoral artery. Foncannon[14] reports the migration of a piece of glass 2¾ by 1 by ¼ inch in size from the posterior to the anterior wall of the chest. Two cases of migration of a Kirschner wire from the shoulder region into the lung are reported by Mazet.[15] In less than three hours a sewing needle wandered from a wound a hand's breadth above the elbow to the forearm.[16] In 1920 Meyer-Pantin[17] collected reports of 12 [illegible] es in which [illegible] se in which [illegible] below the [illegible] the end of the needle was visible. It was pulled out by means of an artery forceps. Hinton[19] reports a fatal case in which a needle used to aspirate the chest accidentally broke off. After a seven day interval, thoracotomy was done without an attempt to remove the needle. Three hours afterward the patient died suddenly, and at postmortem examination the needle was found piercing the heart. In the case reported by Rea and Hoover,[20] a needle apparently passed [illegible] ortem examina- [illegible] ound reports of [illegible] 1851 Winzar[22] described a case in which "by free use of his common bleeding lancet" he removed from beneath the skin of the lower portion of the abdomen a silver teaspoon, three pieces of whalebone and a piece of red cloth. [illegible]

[illegible] an empty stomach. Two and o[illegible] the skin at the border of the st[illegible] became lodged in the upper part of the esophagus. The pin became dislodged, slipped by

the epiglottis, through the larynx and down the trachea to the right bronchus. Later it was coughed up, reswallowed, transmitted along the alimentary tract and finally expelled from the rectum. Martin[25] cut down upon a needle which had been shown by *x*-ray the day before to be in the palm of the hand. It was finally found under the annular ligament, 4 inches away. In Jacobaeus'[26] case a *migrating needle* caused *spontaneous pneumothorax*. David[27] reports a case in which a fish bone was accidentally swallowed and was said to

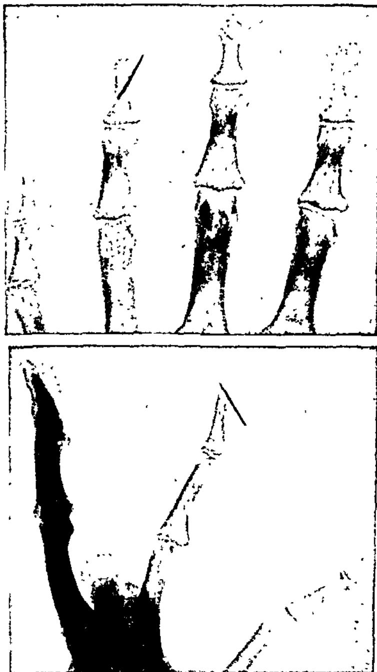


Fig 52.—Anteroposterior and lateral views of a needle in the finger tip.

have been expelled via the urethra after two years and five months. Rubesch[28] reports a case of embolism of a bullet from the heart to the right femoral artery. A case has been reported in which a scrap of projectile was found in the right lung which had entered the right thigh six years before.[29] De Tarnowsky[30] reports a case in which two sewing needles which had been pushed through the epigastrium fifteen years previously were removed from the falciform ligament and the right lobe of the liver, respectively.

One of the most extraordinary cases is that reported by Liebe.[31] A 17 year old girl believed that she had a splinter in her right great toe and tried to pick it out. She succeeded in grasping the object and, on pulling it out, found to her astonishment that it was a horsehair, 8 inches long. She had played about horses as a child, and it was thought that she might have swallowed it.

Smith and Priestly[32] report on a patient who swallowed a pine needle, which was found about ten years later, when it was removed from an inflammatory tumor of the abdominal wall.

Henderson and Gaston[33] report that of 800 cases of *ingested foreign bodies* at the Boston City Hospital, perforation occurred in only 9. The average time required for passage of all types of ingested foreign bodies in 69 cases was 5.1 days. The most rapid passage was 1 day (in a 10 month old infant who had swallowed a pin). The longest time required was 37 days (in a 2½ year old child who had swallowed a nail). No correlation was observed between the age of the patient and the time required for a foreign body to traverse the gastrointestinal tract. The nonsharp foreign bodies traversed the gastrointestinal tract in an average of 4.8 days; those pointed at one end, in an average of 5.8 days, while those pointed at both ends required an average of but 4.6 days, owing probably to the fact that "those pins which pass have the spring end foremost, while the two after-coming tips spread out in wedge fashion and may become entangled in the intestinal content and be carried along with it."

Henderson and Gaston urge that "treatment for an ingested foreign body in the absence of perforation should always be conservative, until it is definitely shown that the foreign body will not pass naturally or until it is evident that there is, or is about to be, perforation. Careful daily examinations of the abdomen should be made. With the development of abdominal tenderness, laparotomy should be performed without delay." Swartz[34] reports a case in which a thermometer was removed from the esophagus with the aid of an esophagoscope. In Heron's[35] case, a swallowed denture was removed three years later by gastrotomy.

Sauer[36] recommends the method of Boot in facilitating the passage of swallowed foreign bodies. The patient is fed a "good-sized bowl of mixed vegetables—cabbage, green peas, and celery. The vegetables should not be cooked soft, and should be swallowed without much if any mastication. Wash them down with a little water if necessary. Give no laxative."[37]

Grob[38] has successfully removed magnetic metallic foreign bodies from the stomach in four cases by the use of a gastric tube to which "a small cylindric solenoid is attached; the solenoid is supplied with electricity from a battery by means of two wires which course in the lumen of the tube. Using a tension of approximately 2 volts, the solenoid is capable of carrying a weight of up to 250 Gm.; with this tension, no appreciable heating of the solenoid will take place and mucosal burns need not be feared. The solenoid is introduced into the stomach and the electric circuit is closed, fluoroscopy being carried out at the same time; the foreign body will be attracted to the solenoid by the electrically produced magnetism and can readily be removed together [illegible] not present any difficulties, as the foreign boc[illegible] tudinal axis of the tube."

Persfow[39] studied 225 cases of swallowed foreign bodies treated in seven Swedish hospitals. He found that objects pointed at both ends readily become stuck during passage, giving rise to severe complications. Spontaneous evacuation of practically all other objects may be expected. Macmanus[40] reports the perforation of an incarcerated intestine by a piece of wire and also perforation of the cecum by a toothpick. This author analyzed 93 cases collected from reports in the literature and found that 73 per cent of the perforations occurred in and around the ileocecal region. The surgical mortality was 53.5 per cent before 1900 and 10 per cent thereafter.[41]

Swanson[42] reports a Fourth of July accident in which an air pump plunger rod was driven through the head. The rod was extracted and, save for temporary paralysis and [illegible]

Glass is a common foreign body following shattering of windshields, broken windows, etc. Dell[44] has found that fragments of shatter-proof glass are visible roentgenographically. Porcelain and pottery have been found in wounds

of the feet. Rust from iron nails has been left in the tissues after the withdrawal of the nail from a puncture wound. Vegetable substances, such as beans, which may be found in the orifices, and thorns, which may become embedded in the skin, have been reported. Animal matter, such as insects, which may enter the external meatus, or eggs of insects may be found. Certain objects in the lumen of the intestine may become foreign bodies by virtue of their inability to pass. In this category may be mentioned hairballs of the stomach (trichobezoars) which come about from the habit of eating hair and the consequent formation of a large hairball which does not pass from the stomach. Murphy buttons, which are less in use now than formerly, have occasionally acted as foreign bodies and caused intestinal obstruction.

Symptoms of foreign bodies depend upon the time which has elapsed since their entry into the tissues. In a fresh wound the symptoms incident to the wound itself may predominate over that of the foreign body. A bullet buried in the soft parts, if not striking any vital organ or vessel, may cause practically no symptoms, and its presence may be indicated only by the fact that there is a wound of entrance and not a wound of exit. The bullet itself in many cases may be palpated just under the skin. Its removal under local anesthesia

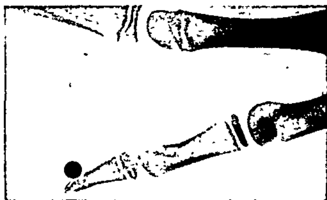


Fig. 53.—BB shot in finger tip.

will then be a simple minor surgical procedure. Many curious wounds have been occasioned by bullets, and the indication of the buried bullet may be problematic without a roentgenogram. Two bullets fired in quick succession have been known to cause but one wound of entrance and two wounds of exit and would give rise to the expectation of finding a bullet in the body were it not for *x*-ray proof that it was not there. The alleged case of a British soldier in the Boer War is of interest. This patient suffered a wound occasioned by a single bullet. The wound of entrance was in one heel and the one of exit in the opposite heel, the only explanation being that the bullet traveled up the leg, across the pelvis and down the other leg. Bullets or portions of shrapnel which are buried in the soft parts in proximity to a nerve or in a situation where weight bearing is common, as in the foot or in the buttocks, frequently cause pain and must be removed on that account. The fate of a foreign body depends to a great extent upon the organisms which are carried in with it. Many small foreign bodies, however, cause absolutely no symptoms and need not be removed unless the patient demands their removal and there appear to be psychological reasons for doing so. Wounds made by cartridge wadding which is fired from a blank cartridge may be very trivial externally,

and the surgeon may be misled into thinking that no foreign body is present. In all such cases, however, it is important to explore the wound for the presence of wadding. A boy placed his finger over the muzzle of his BB rifle and pulled the trigger. The BB shot buried itself in the finger tip. The wound of entrance was scarcely perceptible, and had it not been for the unusual amount of pain, *x*-ray examination, which revealed the true condition, would not have been made (Fig. 53). It is a common occurrence for a surgeon to break a needle during an operation, and it is extremely important to remove the needle at the time of the accident. If this is not done, a needle in the foot or hand may cause considerable pain and, moreover, may lead to considerable adverse comment and possibly a lawsuit. In fresh wounds of the face small portions of glass often are not apparent. After the wound has been cleansed a *reasonable* search for glass fragments should be made. It is better judgment, however, to risk the leaving in place of a small glass fragment than to disturb the wound to such an extent that infection may be introduced. Small fragments of glass which have been overlooked tend to work themselves to the surface, where their presence is manifested by a *tender swelling*. This working to the surface may be accompanied by suppuration, and not uncommonly the foreign body will extrude itself spontaneously. Some glass fragments are visible roentgenographically. If, however, the small portion of glass is suspected by reason of the small painful swelling, a search for it should be made under local anesthesia. Foote[45] wisely says:

> "If the examiner cannot feel the foreign body distinctly, and if he does not cause pain every time he makes a certain pressure, he will do well to postpone operation until more definite symptoms are present or until a radiograph shows the exact situation of the object. Sometimes a patient, feeling pain in a scar, attributes it to the presence of a foreign body, although it is really due to pressure of the scar upon nerve fibers."

Fragments of wood splinters may be found in the skin, under the skin and under the nails. It is said that 80 per cent of injuries from wood splinters become infected. Unless very small and superficial, all wood splinters should be removed. Bristles from tooth brushes may become embedded in the gums or between the teeth and the gums and cause irritation until they are removed. Buried wood splinters may be very deceptive. The patient rarely remembers just what happens when a splinter enters and can, with difficulty, describe the shape of the fragment which was broken off outside. Two cases in point are the following: A young woman accidentally struck her foot against a splintered piece of wood. A very small wound resulted, and she thought nothing of it until the foot became painful, red and swollen. Her physician admitted her to a hospital, where under moist fomentations the redness and swelling subsided but the tenderness along the dorsum of the foot did not disappear. Finally under local anesthesia an exploratory incision was made, and a splinter 2 inches long was withdrawn. A boy while swimming stubbed his toe against a sharp piece of wood and wounded the distal end. Infection of the toe resulted which had somewhat the characteristics of a paronychia. The appearance of the nail itself was entirely normal. After a week of treatment with hot wet dressings, there being no improvement, it was decided to remove the nail. Buried under the nail and entirely invisible from the outside was a wooden splinter 2 cm. long and 4 cm. in diameter. A common accident is for a child to have buried splinters in the buttock as a result of sliding down rough boards. The child may have no memory of the accident whatsoever,

and the mother's attention is called to it by his reluctance to be seated at the dinner table. Examination will reveal a very small wound on the buttock the neighborhood of which is tender to palpation. The diagnosis of a buried splinter may be made with reasonable certainty. An excellent instrument for the removal of splinters is the sharp-pointed "catchless" forceps (Fig. 54).

Removal of Foreign Bodies Which Have Entered through Wounds.—Direct search will reveal many small particles of glass or needles which have been buried in wounds. This operation must not be undertaken lightly, and the patient should be advised of its difficulty and of the chances for failure. It must not be undertaken without proper assistance, proper lighting, *x*-ray machine, fluoroscope and proper instruments. The binocular loupe described by Lahey[46] (Fig. 55) is of great value. The wound should be made as dry as possible, and if necessary a tourniquet should be applied. It is extremely

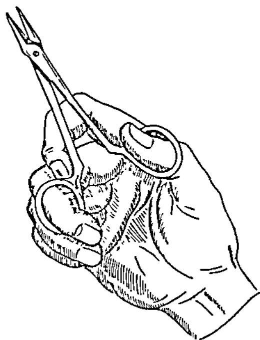


Fig. 54.—Splinter-grasping forceps. Note the absence of a ratchet catch and the fine cross-striated blades.

important to remember not to persist in an unsuccessful search over too long a period. Frequently overzeal in this regard has brought about serious damage to the soft parts. It is better to start afresh a second time after renewed efforts at localization. In the case of needles and other particles opaque to the *x*-ray, localization by means of *x*-ray plates will be extremely useful. A great variety of ingenious methods has been described. Many of these include the placing of opaque markers, as metal rings, hypodermic needles buried in the flesh, etc., to facilitate the *x*-ray localization. These methods have been carefully described by de Tarnowsky.[47] The six chief methods and instruments in use are: first, the two-wire double tube shift method; second, the parallax method; third, the tube shift method with medium triangulation; fourth, the profundometer; fifth, the Hirtz compass, and, sixth, the cannula and trocar with harpoon. The Girdner or Alexander Graham Bell telephone probe was described by Davidson[48] in 1915 and by Bulkley[49] in 1917. The searching

probe is connected to ear-pieces on the surgeon's ears, and when contact is made with the foreign body a click is heard. Davidson said that the telephone probe was suggested to him by an article in the *London Lancet* of Jan. 20, 1883, which described attempts to determine by electrical means the position of the bullet in the body of President Garfield in the two months which elapsed between his wounding and his death in the summer of 1881. The Berman "locator" described by Moorhead[50] is valuable in that it is responsive to any kind of metal. This locator has been found valuable in industrial practice[51] and in the navy.[52]

A method in vogue during World War I but not at present generally available is the use of an electrical vibrator. The instrument when brought in the neighborhood, say 3 or 4 inches, of a steel foreign body will cause it to vibrate in the tissues, and the palpating finger when placed in its neighborhood may feel the foreign body vibrate and in this way localize it. A similar method is described by Oberdalhoff,[53] who emphasizes the value of non-metallic (plexiglass) retractors.

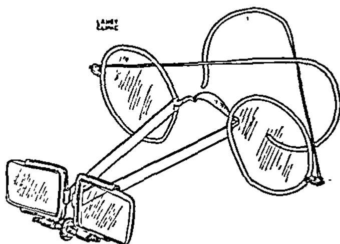


Fig. 55.—Binocular loupe. (Lahey, F. H.: J. A. M. A. 95: 1975, 1930.)

Another method makes use of an instrument, described by Wright,[54] which may be introduced into a wound. This has two electrical contact points; when both of these are placed in contact with a metal foreign body, the circuit is closed, thus lighting a small electric light bulb in the handle of the instrument. Webb[55] devised a method of removing a broken needle from a finger. After anesthetization of the finger with novocain and application of a tourniquet, a small incision enlarging the wound of entrance or over the previously observed tender point is made. The room is then darkened, and a sterile black cloth with a hole 1 cm. in diameter in the center is placed over the upturned reflector of a goose-neck electric light. When the finger is placed over this opening and the wound edges are retracted, the finger is illuminated in its interior. Pressure is then made with a probe in its various parts, and the foreign body is located by its shadow and is readily removed. Oberdalhoff[53] directs attention to two new instruments for the detection of metallic foreign bodies. The first one is the "boloscope," which was developed in the Netherlands. Two pencils of roentgen rays are so focused that the foreign body is at their point of intersection. The pencils of rays from two direction lamps which are coupled with the roentgen rays likewise converge on the foreign

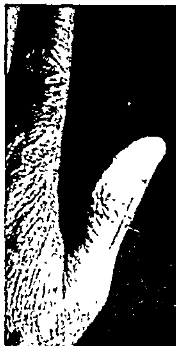


Fig. 56.



Fig. 57.



Fig. 58.

Fig. 56.—Photographic view of localizing pins inserted at right angles to each other into small portion of the epidermis of the left thumb.

Fig. 57.—Perpendicular x-ray view with localizing pins in place.

Fig. 58.—Silhouette x-ray view of foreign body in the extensor tendon of the left thumb, localized by crossed pins inserted into small portion of the epidermis (McNealy, R. W., and Willems, J. D.: Am. J. Surg. 18: 268, 1932.)

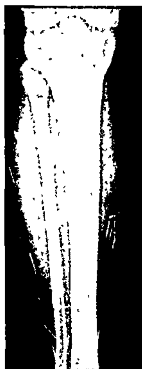


Fig. 59.—Needles introduced into the leg by a man drawing government compensation (Northwestern University Surgical Dispensary.)

body and thus lead the surgeon to the foreign body under ordinary light. McNealy and Willems[56] are guided in the removal of small particles from the hands, fingers and feet by passing through the superficial layers of the.

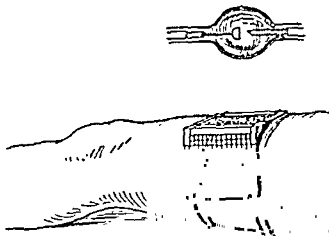


Fig. 60.—Schematic drawing of position of screen and roentgen tube. (Ellis, J. D.: Surg., Gynec. & Obst. 63: 772, 1936.)

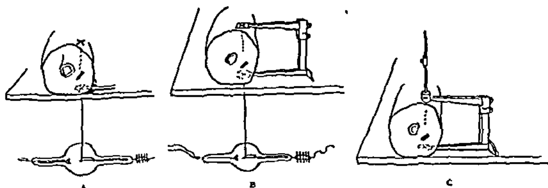


Fig. 61.—*Basic Principles of Two-Point Method:* Drawings that illustrate the accuracy of the two point method rejected by the Army. A, a foreign body embedded deep in a [illegible]

by a ring marker that is moved about beneath the part until its image on the screen encircles the foreign body. Thus the foreign body is directly in line between the upper and lower marks "X." B, *roentgenologic caliper:* A convenient device or caliper for making the upper and lower marks at one time. By fluoroscopy or on a film one sees the ring marker, foreign body and square with the cross wires all *in line.* C, *surgical caliper:* A surgical instrument that is the counterpart of the *x*-ray caliper, is so designed that the distal end of the lower arm is attached to the skin at the lower mark "X" and then the part is adjusted so that the pointer at the distal end of the upper arm rests on the "X" on the upper surface. A knitting-needle-like pointer in the upper arm points directly to the lower mark and thus to the bullet and guides the surgeon to the foreign body. A stop on the pointer indicates the depth previously determined by a double shift of the tube, using any one of several mathematical formulas, or a sliding square to eliminate computation. (Cole, L. G.: Am. J. Surg. 60: 3, 1943.)

skin two needles at right angles to aid in *x*-ray localization (Figs. 56–58). Ellis[57] aids *x*-ray localization by means of a right-angled screen (Fig. 60) and the injection of a few drops of colored roentgen-opaque oil at the site of the foreign body. Some of the oil is expressed as the injecting needle is removed,

leaving a trail which facilitates surgical removal. Cole[58] strongly recommends localization by the two-point method, which he says is more accurate than that used by the Army. Cole's method may be understood by reference to Fig. 61 and its legend.

Several methods have been devised to remove *fishhooks* so buried in the skin that the barb is below the surface. The most practicable way is to force the fishhook on through the skin so that the point and barb project out above the skin. The point or the shank is then clipped off with a scissors or a wire cutter, and the part in the finger is withdrawn (Fig. 62).

Fluoroscopic Removal of Needles and Other Foreign Bodies.—The fluoroscopic removal of foreign bodies should seldom be employed because of the danger to the surgeon's hands. When it seems necessary to use this method

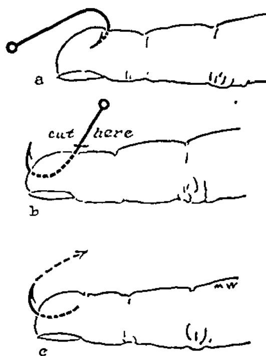


Fig. 62.—Removal of a fishhook embedded in the finger: *a*, the barb prevents withdrawal; *b*, the hook pushed on through the finger, and the shank cut off; *c*, the tip pulled on through.

the *time of x-ray exposure must be carefully taken*, and the procedure should not be repeated for many months. Localization by *x*-ray films is much superior. In describing his combined fluoroscopic and direct vision method of removing foreign bodies, Fitzwilliams[59] has aptly said that localizers and electric probes are of little value. No attempt should be made to remove any needle or foreign body without having the assistance of a fluoroscope immediately available, unless the case is one in which the maneuver described by Doran[60] can be employed. In a few cases Doran was able to force the point of the needle up through the skin and thus withdraw it. Bettman's[61] operating fluoroscope is extremely useful. The fluoroscopic screen is attached to the head and is provided with a hinge so that it can from time to time, as may be necessary, be moved aside to permit direct vision. It is best to undertake the removal only in the fluoroscopic room. A standard technic is as follows:

If the needle is in the hand or extremity and of such density as to be visible with the fluoroscope, the surgeon is fortunate. However, in the case of a very fat individual with a very thin needle, such as a hypodermic needle, the fluoroscope may have no value at all. The extremity is first carefully cleansed and painted with iodine and is so draped that it can be moved in all directions without contaminating the field. An x-ray plate has been made previously and the most probable site of the foreign body decided upon (Fig. 63). Under

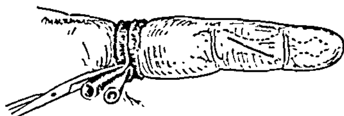


Fig. 63.—Removal of foreign body from the finger. A constrictor is applied prior to injection of local anesthetic solution. De Takáts and others believe the constrictor to be unnecessary and painful when nerve block anesthesia is obtained.

local anesthesia an incision ½ inch long is made over the site. A small artery forceps is then inserted into this wound in the supposed direction of the foreign body (Fig. 64). The surgeon carefully holds the artery forceps in place, and the room is darkened. After a sufficient interval to accustom the eyes to the darkness, the fluoroscopic screen is held over the extremity, care being used not to touch the surgeon's hands or instruments and contaminate them. A sterile towel may be placed over the surgeon's hands. By means of

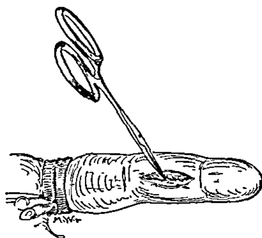
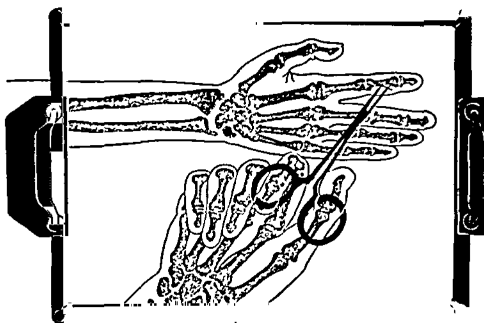


Fig. 64.—The skin incision has been made under local anesthesia. The mosquito forceps is inserted into the wound in the approximate location of the foreign body *under direct vision*.

the fluoroscope the surgeon then attempts to force the tip of the hemostat, *without* opening it, down to the foreign body. When it has reached the foreign body he opens the hemostat and attempts to fix the foreign body in its grasp (Fig. 65). Assurance that he has grasped the foreign body may be obtained by moving the hemostat and seeing the needle move with it as one piece. This procedure sounds simple but may be extremely difficult because of the poor stereoscopic vision. The surgeon may find that the hemostat is ½ inch above

or below the foreign body and may be considerably perplexed to find out why he does not grasp it. It is important in operations of this type to caution the x-ray technician in advance to observe carefully the time during which the fluoroscope is used. It is very easy to insist that the fluoroscope be kept



on longer than is safe for the surgeon's hands or the patient. A safe total time limit is eight minutes, but this is subject to variations according to the type of x-ray machine used. Moreover, the surgeon dare not use this type of procedure too often himself for fear of x-ray burns. After the foreign body has

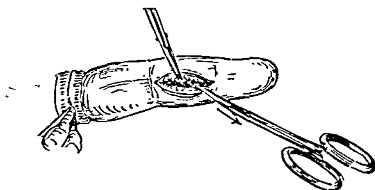


Fig. 66.—The hemostat which has grasped the foreign body is used merely as a guide. The foreign body is exposed by careful dissection and is removed with a second hemostat.

been grasped with the hemostat, *no attempts should be made to withdraw it forcibly*. The room should be relighted and the fluoroscopic screen removed. Using the hemostat as a guide, the surgeon should carefully dissect down the wound until the needle comes *into view*. At this point the needle should be grasped by *one end* and carefully withdrawn (Fig. 66). Overhaste in attempts

to remove the needle frequently has caused it to be broken in several parts and has greatly added to the difficulty of the operation. The wound may be closed with a few sutures and generally without drainage. The method of Prioleau[62] is as follows: "Under local anesthesia, a pair of mosquito forceps is inserted through a small incision under fluoroscopic control. The body of the needle is grasped and manipulated so that one end presents under the skin, permitting its removal through a second small incision. Possible danger attendant upon open operation is avoided."[63]

Broken Spinal Puncture Needle.—Spinal puncture needles are not infrequently broken. This accident may occur as the result of a defective needle, as from internal rusting, or because of a sudden movement of the patient. Wayne Babcock[64] says that the safest materials for spinal puncture needles are nickeloid, iridium-platinum or the more flexible rustless steel alloys. The fragment of the needle should be removed as soon as possible. Local anesthesia is feasible for this purpose, but general anesthesia is to be preferred. The dissection should be carefully made, with the guidance of roentgenograms and traces of rust along the needle track. "Fortunately, the portion of the needle is rarely as difficult to remove as a bit of needle from the hand or the deep tissues of the arm" (Babcock).

The method of Lahey[65] for the removal of broken spinal anesthesia needles is as follows:

"If the spinal anesthesia has already been induced above the level of the needle puncture before the accident has occurred, no further anesthesia will be necessary. If not, then a general or another spinal anesthesia must be induced. The point of puncture in the skin marking the point of entrance of the broken needle should first be marked by a small transverse skin cut, in order that it may not be lost and thus uncertainty arise as to the interspace within which the broken segment rests. Next, a generous longitudinal incision is made directly over the spinous processes. The aponeurosis over the erector spinae on each side of the spine is incised for the full distance of the skin incision, the muscles on each side of the spinous processes being separated well down and a little outward on the laminae of the vertebrae, and held outward with retractors. With this exposure, the index [illegible] the inter- [illegible] ght-angled [illegible] e spinous processes. Should this be the case, with the erector spinae muscles on each side well retracted, the points of a right-angled hemostat with the jaws opened are passed between the spines and the interspinous tissue is gently grasped and upward traction made on it until the needle is found.

"In the 3 cases, the ends of two needles have been found in the lateral position and one needle was found in the interspinous position."

MISCELLANEOUS FOREIGN BODIES

Eye.—All varieties of small foreign bodies may be found "in the eye." A bent pin used as a missile for a sling shot has been known to penetrate the eyeball. Steel fragments which have been loosened by hammering steel, portions of emery from emery wheels, etc., are common foreign bodies in the eye. Cinders may be found in either the upper or the lower conjunctival sac. In the search for a cinder the lower lid should first be pulled down; the cinder may be apparent immediately and removed on the tip of a small, tightly wound cotton applicator which is preferably moistened with boric solution. If it is not apparent on the lower lid, the upper lid should be everted. This is done by having the patient look down, and then, by grasping the eyelashes, turning back the upper lid over a small applicator or probe (Fig. 67). The foreign body if present is then generally seen and can be removed with a (moistened) cotton swab. In apprehensive persons it may be necessary first to instil a drop or two of 2 per cent cocaine solution. In case the cinder is not sighted, the surgeon should look for the foreign body embedded in the cornea. This

generally can be seen with a magnifying glass under oblique illumination. The patient, moreover, will frequently say that he is free from pain when the eyelids are opened but that he feels the scraping on winking. It is far better to refer all such patients to an ophthalmologist, as unskilful attempts to remove a foreign body from the cornea may cause infection or perforation of the anterior chamber. When, however, it is necessary to attempt removal, it should be done under cocaine anesthesia with the best illumination possible and with the aid of a magnifying glass. A sterile tiny spud or a scalpel with not too sharp a point or even a cotton applicator is useful. After removal of foreign bodies from the eye, 0.5 to 2 per cent mercurochrome or 5 per cent argyrol should be instilled by the surgeon, instructions being given to wash the eye with saturated boric solution by means of an eyecup several times daily. Some authorities prefer to wash by means of an eyedropper, believing that the eyecup in the hands of the laity is uncleanly.

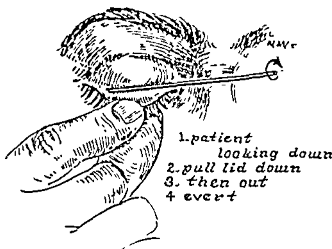


Fig. 67.—Eversion of the upper eyelid. The patient is instructed to look down. The lashes are grasped, and gentle pressure is made upon the lid with a toothpick or a match stick. The lid is then everted.

Nose.—All manner of foreign bodies are introduced into the nostrils by children. Bolts, nuts, screws, beans and particularly marbles find their way into the nose. Richards[66] has in 2 cases removed a metal button which had been present in the nose for several years. The removal of such foreign bodies may be extremely difficult, and the difficulty is greatly augmented if there has been considerable delay after the accident and edema and infection have occurred. A unilateral nasal discharge is always suggestive of a foreign body (Vaughan and Burnham). Many foreign bodies can be removed by encouraging the child forcibly to blow his nose with the opposite nostril occluded. Small sharp objects can be grasped and withdrawn with a hemostat. Round objects, such as marbles, are handled with a curet or hook which may be formed by a bent probe and which is insinuated behind the object. In many cases it is necessary to push the foreign body back into the pharynx and remove it through the mouth, taking care that it does not slip back into the throat. If considerable swelling has taken place, the turbinates are shrunk by 3 per cent ephedrine or cocaine solution before an attempt to remove the foreign body is made.

Ears.—Children may introduce small objects into the external meatus, and their presence will become evident by pain, swelling and occasionally discharge. Small insects may enter the external meatus and remain there and deposit their eggs. The small foreign objects may be removed under direct vision with a small forceps. Insects, when alive, will sometimes come out of the ear if a bright light is placed near the opening of the canal. Insects may be killed by the introduction of olive oil and their removal effected by syringing with warm water. Impacted or inspissated wax in the ear is most generally removed with an instrument or with copious and continued irrigations of warm water or sodium bicarbonate solution. A plug can be softened by packing against the mass a cotton pledget soaked in peroxide of hydrogen. This process may have to be repeated several times (Fig. 68). A large plug occa-



Fig. 68.—Irrigation of the external auditory meatus. Warm water or saline solution is useful in the removal of inspissated wax. (Maisonnet, J.: Petite chirurgie, Paris, Gaston Doin et Cie, 1928.)

sionally has to be removed by grasping it with a forceps. The latter procedure may be best trusted to an otolaryngologist. After removal of a foreign body from the external auditory canal, Rosenwasser[67] recommends the application of 5 per cent ammoniated mercury ointment to the walls of the canal.

Pharynx and Esophagus.—Coins, toy bicycles and other small objects may become lodged in the pharynx or esophagus. Fishbones may become caught in the act of swallowing and may penetrate the mucous membrane in the region of the tonsillar pillars or the posterior pharynx. The introduction of a finger into the pharynx may permit the hooking out of a foreign body, or it will often bring about such violent gagging and vomiting as to extrude it. If, however, this is not effectual, a curved forceps should be introduced into the mouth, and under the guidance of the palpating finger the foreign body should be grasped and removed. A fishbone, if visible, can cautiously be removed with a forceps. Occasionally the aid of a laryngeal mirror may be required. The swallowing of a fishbone may cause a wound of the pharynx

that for a few days makes the patient think he has an embedded fishbone, but the symptoms will subside. The tonsils and base of the tongue are common sites of pin or fishbone lodgment.

McReynolds[68] reports the case of an intoxicated person whose full plate of upper teeth became accidentally lodged in the upper part of the esophagus. Heyd[69] reports the case of a girl of 14 years who swallowed a 2½ inch black-headed pin. On laparotomy the point of the pin was found to be perforating the jejunum. It was successfully removed. In Palmer's[70] case an 8 month old baby swallowed a 1½ inch open safety pin. It was observed roentgenologically until it passed safely. Palmer believes that "in the majority of instances one can count on the passage of a foreign body through the intestine if it has been able to pass through the pylorus." A nail swallowed by a 2½ year old child passed in fourteen days.[71] Shie [72] reports a case in which some four months after the neck had been wounded by fragments of a broken windshield, a fragment of glass 2½ inches by 1 inch was removed from the glottis at the base of the left tonsil. Moore[73] reports on a 15 month old girl who had been unable to swallow solid food without vomiting since the age of 4 months. A gold ring was found in the esophagus and was successfully removed by means of an esophagoscope.

Foreign bodies in the esophagus which have sharp points are best removed by means of an esophagoscope and forceps. It is surprising, however, how many coins, open safety pins, needles and tacks will pass without apparent injury to the esophagus, into the stomach and, in fact, through the entire gastrointestinal tract. Certain sharp objects which are embedded in the wall of the esophagus will require esophagotomy for removal. By careful use of an esophageal bougie or a stomach tube or by having the patient swallow lumps of bread or potatoes, rounded objects may be forced on into the stomach, where they are more safely situated. Galloway[74] believes that even rounded objects such as pennies should be removed when lodged in the esophagus of a young child. Rounded objects do not always necessarily pass into the stomach but may cause pressure erosion of the esophagus with perforation. Removal or movement into the stomach is best effected by means of the esophagoscope.

Trachea.—Patients with large foreign bodies which completely obstruct the trachea rarely survive long enough to reach the physician's hands. Foreign bodies which partially obstruct the trachea and merely cause a wheezing and embarrassment of respiration do not immediately threaten life and can be removed with more deliberation. Rounded objects, such as coins and beans, occasionally can be expelled by inducing the patient to cough. Sometimes they can be removed by means of the laryngeal mirror and a long curved forceps. This, of course, is best accomplished in the hands of a trained laryngologist. Chevalier Jackson[75] has made the most valuable studies of foreign bodies in the air and food passages. He has removed foreign bodies through the laryngoscope, the bronchoscope and esophagoscope. In 98.1 per cent of 628 cases, removal was successful. The operative mortality was less than 0.5 per cent. One of his most interesting cases was that of a woman who had had a glass collar button in her lung for twenty-six years. Septic toxemia had reduced her weight to 98 pounds. She regained perfect health after the removal and reached the weight of 182 pounds. Boheme[76] reports the successful removal of a bean from the trachea of a 13 month old infant.

On rare occasions the surgeon may see a case of complete tracheal obstruction very shortly after its occurrence. The patient is cyanotic and *in extremis.* A few brilliant results have been recorded after immediate emergency tracheotomy. An infant in the neighborhood of the Johns Hopkins Dispensary was

rushed there in his mother's arms immediately after the lodgment of a bean in his trachea with complete obstruction. The resident physician, sensing the urgency of the situation and the futility of waiting for aseptic preparation, did a tracheotomy with his pocket knife and saved the baby's life. Tucker[77] reports a case of a child with a "kewpie" doll in his larynx. The patient was saved by immediate tracheotomy and the doll removed later. When tracheotomy is imperative the patient should be placed on the table so inclined that the head is downward at an angle of at least 15 degrees. This is done in order that any blood that enters the trachea will run out into the mouth instead of down into the lungs. With a good light and what assistance may be available, the surgeon makes an incision in the midline of the neck in the lower half and directly over the trachea, precaution first having been taken to produce upward traction on the thyroid cartilage. Two or three of the cartilaginous tracheal rings are cut through at a distance of some 2 cm. below the thyroid cartilage. If a tracheotomy tube is available, it is inserted. If no tracheotomy tube is at hand, hairpins bent to form small retractors may be used to divulse the cut edges of the trachea, and breathing may be established without the insertion of a tube. In some instances it will be necessary to clip a small portion of the ring on each side so as to make a circular hole in the trachea. The convulsive inspiratory efforts of the patient will often cause the rings to collapse and shut off the trachea. This accident does not occur when the tracheotomy tube is in place, but in the absence of a tracheotomy tube it may be avoided by suturing the cut margins of the trachea up to the overlying muscles, or by the insertion of a twisted hairpin, self-retaining retractor.[78] In cases in which a tracheotomy tube is used, it is important accurately to instruct the nurse in charge of the patient as to the details of cleansing the inner tube.

Guisez[79] warns that "the death of young children from bronchopneumonia or purulent pleurisy, due to the presence of an intrabronchial foreign body, is of more frequent occurrence than might be supposed." Unexplained bronchopneumonia should arouse suspicion of the presence of a foreign body *even if the latter is undisclosed by means of roentgenograms*, and bronchoscopic examination should be instituted.

Wishart[80] quotes Chevalier Jackson's list of the things which should *not* be done when a patient is suspected of having swallowed some kind of foreign body:

"1. Do not reach for the foreign body with the finger, lest the foreign body be thereby pushed into the larynx, or the larynx thus be traumatized.

"2. Do not make any attempt at removal with the patient in any other position than the recumbent, with the head and shoulders lower than the body.

"3. Do not hold up the patient by the heels, lest the foreign body be dislodged and asphyxiate the patient by becoming jammed in the glottis.

"4. Do not fail to have a radiograph made, if possible, whether the foreign body in question is of a kind dense to the ray or not.

"5. Do not fail to search endoscopically for foreign body in all cases of doubt.

"6. Do not pass an [illegible]

"7.

inatio[illegible]

Minor surgery is not concerned with those cases of multiple foreign bodies in the stomach which require gastrotomy for removal. Dr. W. S. Halsted removed 208 foreign bodies and 74 Gm. of glass from the stomach of a patient, and many other similar instances are recorded.

Penis and Urethra.—The introduction of a foreign body into the urethra is a rather common occurrence, particularly in the female. All manner of foreign bodies have been used; pins, nails, hairpins, pieces of wire, etc., have been introduced for various distances. A pipe cleaner was reported by Last.[81] One of these may be left in, protruding from the meatus, and the patient comes to the physician because the swelling will be so marked that he will be unable to extract it. It may be palpated in the penile urethra or seen with the endoscope. General anesthesia may be necessary to permit its removal. When a foreign body has actually entered the bladder, it will be necessary to refer the patient to the urologist for cystoscopic treatment. In *many cases it will be possible to remove the foreign body through the cysto*scope. In others, cystotomy will be necessary. Foreign bodies which have been allowed to remain in the bladder for a long period of time will become encrusted with salty deposits or in some cases will ulcerate through the bladder wall and cause an abscess formation in the peritoneal cavity or the perineum. Many small foreign bodies may be removed from the male and female urethra by means of a urethroscope and a small but long forceps. The urethra at the base of the penis must be compressed during this maneuver to prevent the foreign body from slipping into the bladder (Foote). It may be necessary, however, in some cases to do an external urethrotomy in the male. Jeck[82] calls attention to the impropriety of opening the pendulous urethra directly over a foreign body. Swan[83] removed a nutpick from the urethra through an external incision. The patient, aged 76, had attempted to dilate a stricture by means of the nutpick. Not uncommonly a pin is introduced head foremost into the urethra. When this occurs it is impossible to force it out because the pinpoint engages in the wall of the urethra. When this occurs a useful maneuver is to force the pinpoint entirely through the wall of the penis and by reversing its direction expel the head out through the meatus.

The penis occasionally is injured by having a ring passed over it. Resulting congestion may prevent the removal of the ring and may even obscure it. The ring will have to be filed or cut in two places.

Bladder.—Foreign bodies, such as hairpins, nails, chewing gum, needles, tallow candles, rubber catheters, pencils and clinical thermometers have been introduced into the bladder. Rudnick[84] reports a case in which a heavy rubber pessary on a flexible metal ring, measuring 3½ inches by 1½ inches, was introduced into the female bladder.[85] Occasionally these foreign bodies can be removed by means of a cystoscope and forceps. Softer objects occasionally can be crushed by the lithotrite. Suprapubic cystotomy under direct vision, however, is a much safer procedure than protracted intraurethral instrumentation.

Rectum.—General anesthesia is frequently necessary for the removal of a foreign body from the rectum. With extreme caution the sphincter ani should be dilated. This is done by first inserting one gloved and well vaselined finger into the anus. The anesthetist is cautioned that the sphincter is being dilated because the marked stimulating effect on respiration caused by dilatation of the sphincter may cause the patient to inhale greater quantities of anesthetic than is desirable. After the first finger has been introduced, the second, third and finally fourth fingers are also introduced. By means of a rectal speculum the foreign body may be visualized and grasped and removed, or occasionally it can be extracted by means of a finger inserted into the rectum or with a

forceps guided by the finger. Impacted feces generally can be removed digitally without anesthesia. McKenney[86] lists the ingested foreign bodies which he has removed from lesions in the lower portion of the rectum or anal canal as follows: "Pieces of apple core, fish bones, splinters of bone, chicken ribs, seeds (poppy, psyllium, caraway, fig, tomato, cucumber, apple, grape), splinters of wood, pieces of wooden toothpicks, toothbrush bristles, hardened feces, pieces of egg shell, piece of lobster shell, fish scale, pieces of enamel from granite ware, pieces of plating from a table knife, child's beauty pin, pieces of fingernail, peach stone splinter, pieces of glass, husk of oat grain, etc." Thorek[87] reports a case in which a screw driver introduced into the rectum was removed from the colon through an inguinal hernia sac.

Vagina and Uterus.—*Small foreign particles in the vagina generally can be removed by irrigations with warm solutions or by means of a vaginal speculum and forceps. A pessary which has been left in position for a long time and which has become partially embedded in the folds of the mucous membrane of the vagina often will have to be cut to pieces with a bone-cutting forceps before removal can be effected. Safety pins have been removed from the vagina of a 4 year old and a 2½ year old girl by Nixon[88] and Miller[85] re-*

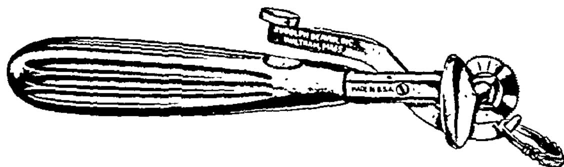


Fig. 69.—Finger ring cutter for removal of a ring from a swollen finger.

spectively. A needle broken off and lost in the uterine wall during an emergency operation was passed from the vagina forty-five days later.[90] (See also the section on foreign bodies in the chapter on the Female Genitourinary Organs.)

Ring on Swollen Finger.—In cases in which a child has worked a tight ring on a finger or an injury has caused a finger which bears a ring to swell, it will be necessary to remove the ring. Often this can be done by gently massaging the edema of the distal part of the finger back under the ring and by anointing the finger with petrolatum or soap. More often it will be necessary to remove the ring by cutting it. For this purpose the Beaver finger-ring cutter* is ideal (Fig. 69). In the absence of this ring cutter, a strong wire-cutting forceps or a file may be used.

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CHAPTER VI

INJURIES BY ELECTRICITY

EVERY year some 1300 persons in the United States die by accidental electrocution.[1] Wadsworth[2] has classified injuries caused by electricity into four types: (1) from currents applied for therapeutic purposes, (2) from industrial currents, (3) from lightning and (4) from radiant discharges—*i. e.*, *x*-ray burns. Usac[3] says there are two general types of local lesions, namely, burns due to an accidentally produced arc and burns resulting from the passage of a current through the tissues. In the first instance the injury is caused directly by the incandescent gases between the conductors. In the second the tissues are heated by the passage of the current through them, which is called the Joule effect. It is only the latter type of injury that is specifically related to electrical action. Such lesions are deep and more extensive than the initial aspect of the tissues indicates. The structures that suffer the most are those offering the greatest resistance to the current, that is to say, the skin and tendons. Extensive aseptic sloughing often occurs and, with healing, tendons become involved in a solid block of scar tissue. Severe grades of disability are the result. With extremely high voltages an entire extremity may be carbonized or, as in one case cited, the entire body.

Pearl[4] has made a careful study of electric shock. He says that, "other things being equal, high tension currents are less dangerous than low tension ones" and that "the voltages in most common use are most dangerous." Alternating currents are probably more dangerous than direct currents. Moist skin offers less resistance to electric current. Pearl says:

"In considering the resistance of the body, the point of exit as well as the point of entrance is significant. Many accidents occur as the result of good contact with the ground. Shoes have a high resistance when dry, but when wet their resistance is so diminished that a current may traverse the body and cause death. Shoes shod with iron nails are particularly dangerous, especially when the ends of the nails have worn through the inner sole. One should remember that concrete, especially if reinforced, is a good conductor.

"The area and firmness of contact are other important factors. A broad surface and firm contact permit the flow of more current at given values than smaller and lighter contacts. As a current passes through the tissues their resistance diminishes rapidly. Currents from foot to foot are never fatal per se, no matter how great the current; yet even a small current *passed through the chest may cause death.*" *The more prolonged the contact, the more* serious the effect, regardless of type of current. The majority of deaths from electric shock occur as the result of uncomplicated ventricular fibrillation. Fibrillation once established is usually permanent (Pearl). Paralysis of the respiratory center is common (Jellinek).

Williams[5] calls attention to the hazard of low voltage shocks. He says that "more lives will be saved if it is recognized that the danger of stimulation of the ventricles and the production of fibrillation are present when contact is made with a low voltage line when the skin is thoroughly wet or when the area of contact is large." Death has been caused by a voltage known not to be in excess of 110 volts. Williams adds that "the human epidermis, when dry, has a great electrical resistance, and under these conditions contact with low voltage lines would not, ordinarily, cause currents of large enough magnitude to pass to bring about the stimulation of the ventricle required to produce fibrillation. It must be remembered, however, that 'dryness' of the epidermis is a qualitative term and what might

[illegible] when the area of contact is large. [illegible] cardiographer knows that thorough wetting of the skin results in the great lowering of the resistance. As prepared for electrocardiography, the resistance across the extremities may be as low as 300 ohms for alternating current. A slight cut or abrasion of the skin has the effect of lowering the resistance greatly.

"A considerable number of fatal accidents have happened to people in bathtubs. Recently a citizen of Philadelphia was found dead in his bath with an electrical apparatus for vibratory massage which he had been using, attendant circumstances making it apparent that death had resulted from electrical shock. Other people have been killed in their bathtubs in attempting to turn lamps on or off or to move electrical fans or heating appliances.

"It is an engineering practice to ground one side of all household power lines, *i. e.*, 110 volt circuits, and this practice has been adopted to protect against fire hazard and the danger of electrical shock in cases of transformer breakdown or contact of transformer primary leads, carrying current ordinarily at from 2200 to 2300 volts with the secondary wires which run into the consumer's house. While such grounding reduces this hazard, a hazard which is *only occasionally present, it increases the low-voltage hazard. Contact with the ungrounded* side of the low-voltage line, when some part of the body is in contact with the ground, becomes dangerous if the skin is wet enough to conduct. There are many places in a dwelling house where excellent electrical contact with the ground can be made. Water pipes, drain pipes, radiators, sinks, and the conduits in which the power wire run are all usually well grounded. A person in a bathtub, making through his wet skin an excellent contact with the grounded drain pipe, runs a deadly risk if he happens to touch the metallic shell of a fixture which is in electrical contact with the ungrounded side of the circuit. Fixtures are not supposed to be in this condition, but there are so many opportunities for them to be, or to become so, that the danger is ever present. The makers of electrical appliances endeavor to develop their products with a view to making them safer, and practice constantly improves. However, even the best equipment is subject to deterioration with use. Sometimes the user thinks himself qualified to undertake the apparently simple repair of his equipment. In so doing he may be setting a fatal trap for himself, even though the device may seem to function properly. To attempt to specify details of construction so as to cover all possible contingencies would result in an enormous increase in costs, much of it unnecessary, and even then occasional accidents would occur. It seems, therefore, desirable to acquaint the public with the fact that it may be dangerous to touch electric lamps and appliances wiht wet hands, especially when there are cuts and abrasions of the skin and particularly when there is a ground current."

Williams[6] says that electric toasters and electric heaters costing less than a dollar are liable to become death traps. This author gives a good discussion of the dangers in the use of various appliances. "To free an individual from a live circuit it is better to use one's foot than a hand; the current is then less likely to reach the heart or respiratory nervous system." (Poehler.[1])

Pearl[4] says: "It is safe to say that at the present time there are no gross or microscopic visceral lesions absolutely indicative of the passage of electricity through the organism or of death from this agent." Fetterman and Smiley[7] report a case of behavior disturbance following brain damage from electricity. Fisher,[8] after studying 870 cases of electric burns, and flashes, concludes that the remote effects have been greatly exaggerated. Reference should be made to Jellinek's book[9] based on thirty years of study.

"Fortunately, the first effect of the current is to cause violent muscular contractions; at times these throw the man some distance, breaking the contact, thus saving his life." (Wadsworth.) The current may be broken if the unsconscious victim falls away from the wire or if the proper switch is thrown.

Burns may frequently occur at the point of contact. These may vary in intensity from erythema to actual charring. The likelihood that the victim has received the whole charge is less if the skin is intact after the injury.

Fruehmann[10] reports the case of a woman aged 34, who while telephoning sustained a

the greater tubercle, but no other changes. When attempts were made to reduce the dislocation, the neck of the humerus fractured. Surgical treatment was resorted to, and the fracture healed, so that the patient is now able to use her arm again. In discussing how, in spite of careful manipulation, the fracture came about, Fruehmann points out that although much is known in regard to the injurious effects of the electric current on the soft parts, little is as yet known about the bone injuries. Jellinek discovered extremely fine fissures in bones that had been exposed to strong electric current. He designated these fissures as scissions. In the roentgenogram they are frequently not detectable, at least immediately following the accident, but after several days they may become visible. Later they usually disappear again. These fissures or scissions have been demonstrated in the bones of patients who have died as the result of contact with a powerful electric current, and it has also been possible to produce them in animal experiments. Electropathologic specimens show that they develop not only in organic substances, such as bones and wood, but also in inorganic substances, such as glass, porcelain and metal. It is probable that they are purely mechanical effects of the current. Fruehmann stresses that if in case of electric trauma there are signs of bone involvement, the bone should be treated with great care and should be immobilized.

Jellinek[11] has given definite indications for surgical intervention in cases of electrical injuries. He notes that the vitality of the tissues surrounding an electric burn for a considerable distance is difficult to judge before several weeks have passed. The electric current leaves an invisible line of demarcation. There is a marked tendency of the affected vessels to embolism and to sudden and profuse hemorrhages. The indications for surgical intervention are profuse hemorrhages, which seldom occur before the third or fourth week. A lumbar puncture should be the first aid rendered at the site of the accident when the victim is unconscious or apparently dead, or upon a conscious patient whenever there are symptoms of cerebral edema or of increased cerebral pressure. Amputations are indicated only when there are serious systemic disturbances. Nerves and tendons may have to be sutured. In another paper Jellinek[12] reports the case of a man whose life was doubtless saved by timely lumbar puncture. This patient came in contact with a current of 5000 volts and collapsed, apparently dead, but was resuscitated by artificial respiration. Delirium, trismus and opisthotonos followed. Lumbar puncture was done with great difficulty, owing to the violent convulsions of the patient, and 25 cc. of bloody fluid was obtained. The pulse improved, and an hour later the patient was fully conscious. Mouzon[13] says that operation is particularly dangerous after electrical injury because the current produces parietal thromboses, which may result in embolism, and causes fragility of the vessel walls which favors the occurrence of secondary hemorrhage.

According to Jellinek[14] high and low tension currents have the same lethal effect, and death is not produced by high amperage or voltage but by a combination of several physiochemical and physiologic phenomena. Alternating currents are more dangerous than direct currents.

Deaths from lightning are more frequent in rural districts than in cities. According to figures of the Surgeon General of the Public Health Service, Dr. H. S. Cumming (given to Dr. Keen), there were 461 fatal cases in the registration area in 1923—possibly 541 in the whole United States.

"During the years 1924 to 1933 there were 3849 deaths due to lightning reported within

"Burns are the most common lesions due to lightning stroke and may be of any degree of severity. Reports of bizarre patterns have been recorded, such as arborescent markings, long narrow lines, localized surface burns, and burns made in shapes determined by metal objects in the clothing or pockets. Associated with the burns, large lacerations may be caused by the explosive force of the lightning stroke. Wehe reported a case in which the soft tissues were torn from the right shoulder area, thereby exposing the upper end of the humerus, the clavicle, and the muscles of that area. Hegner reported compound fractures of the bones of the foot associated with considerable destruction of the soft parts. Perhaps the most common burn is the linear type, which marks the path of the electricity between two points on the body's surface. That part of the body which is in contact with a metal object at the time of injury usually suffers the greatest degree of trauma. In Benjamin's case the patient was driving a truck, and a large burn on his thigh was apparently the point of contact with the car. Elwell reported the case of a boy who received a large burn and laceration of the arm in which he was carrying a metal bucket. Dunscombe-Hanibal reported a patient who received a large burn over the right side of the body and right shoulder where he was carrying a pitchfork.

"Frequently the hair of the head or eyebrows is singed without associated deep burns of the skin. The most unusual report is that of Ashby in which three children developed a left-sided alopecia two weeks after they were struck by lightning. They had a return of their hair in approximately six months.

"Among the organs of special sense that have been affected by lightning stroke are the ears and eyes.

"Lesions of the nervous system following lightning stroke have been very bizarre and varied. The return of function has been so rapid in some cases that the exact location and type of the pathologic lesions may be under dispute." Crawford and Hoopes report a case of lightning stroke with skull fracture in which the patient recovered.

In a storm, animals are more dangerous than an equal amount of metal, because of the enormous surface of damp hair. Trees with a corky bark which offers an enormous surface become more dangerous when the bark is damp than trees with a smooth bark (Wadsworth).

Pearl[4] says that the chief problem in the *treatment* of electric shock concerns ventricular fibrillation. He says:

"No amount of artificial respiration will restore to normal rhythm a fibrillating ventricle. So long as there is evidence of normal cardiac rhythm, the prognosis is good and artificial respiration should be continued. Once the diagnosis of ventricular fibrillation is certain and artificial respiration has not revived the patient within fifteen minutes after the accident, unduly prolonged artificial respiration is illogical.

"The heart sounds may not be audible and the pulse not palpable, yet the heart may be beating feebly. In such cases, however, it is more likely that ventricular fibrillation has been produced. If regular pulsations are noted in the veins of the neck, and no heart movements are heard or felt, ventricular fibrillation is even more likely, as it indicates that the auricles are still functioning rhythmically. The absence of venous pulsations in the neck is not so important, for auricular fibrillation may accompany ventricular fibrillation. The diagnosis is uncertain in most cases. d'Halluin suggested that a drop of ether instilled into one eye will reveal the presence of even a feeble circulation by the redness produced, the other eye serving as a control. During this test the patient should lie horizontal and all other influences which might have a bearing on the interpretation of the result should be excluded. He also suggested that a blunt probe introduced through the skin to lie directly against the ventricle would show the presence or absence of regular pulsations, or possibly the tremulations of a fibrillating heart.

"The presence of ventricular fibrillation having been indicated by a careful test, the surgeon is confronted with a most grave situation. The injection into both ventricles of potassium followed by calcium, and the passage through the heart of a current at higher voltage than that used to produce the fibrillation are likely to stop ventricular fibrillation in man. In order to restore regular rhythm, both of these methods require prompt exposure of the heart for direct massage, a heroic measure indeed, which must be performed before the death of the vital centers (ten minutes). The carotid route for the administration of potassium and calcium has been successful in dogs without cardiac massage, and would be worth attempting in human beings. If these measures were unsuccessful, cardiac massage

could be resorted to. It is therefore clear that the chance of recovery from ventricular fibrillation occurring under the conditions of electric shock is almost hopeless, practically speaking, unless the accident occurs in a hospital or operating room. In favorable cases the surgeon should not shrink from making a quick abdominal incision and massaging the heart. One must realize that grave circumstances call for heroic action, and that, in the words of d'Halluin, 'Un coeur qui tremule n'est pas une coeur mort' (a quivering heart is not dead)."

For practical purposes *artificial respiration* should be used on every victim of electric shock who is not breathing. Fisher[16] says it is a fallacy to regard as futile the working on a shocked and apparently dead individual for any great length of time. He says:

"These cases are in a physiologic state of death and while it is a fact that many have been killed instantaneously by the action of the current on the heart producing ventricular fibrillation still a large proportion of them have had a paralysis of respiration due to the action of the current on the respiratory center in the brain and if supportive measure, as artificial respiration, be given at once and persisted in for a long period of time, many of them will be saved. Permit me here to quote a few statistics, which, dry as statistics are, will be enlightening as well as encouraging:"

Current	*Voltage*	*Time to Resuscitate*
A. C.	200	16 minutes
A. C.	220	1 hour and 20 minutes
A. C.	240	1 hour
A. C.	400	2 hours and 5 minutes
A. C.	1,000	17 minutes
A. C.	2,300	3 hours
A. C.	4,000	1 hour
A. C.	11,400	2 hours
A. C.	20,000	24 minutes
A. C.	33,000	5 cases each took one hour to resuscitate

Fisher analyzed 205 cases. There were successful resuscitations in 79 cases; in 33 cases recovery occurred without resuscitation and in 93 cases resuscitation was unsuccessful. In the 1937 "Year Book of General Surgery," Evarts Graham reports the following case: Under date of Nov. 10, 1936, a United Press dispatch from New York stated that a man aged 25 survived 55,000 volts from wires carrying a current of 40 to 70 amperes. To cause almost instant death in the electric chair, only 22,000 volts with an amperage of between 20 and 30 is used. This man was knocked to the floor, 10 feet below. When workers reached him his heart beat was imperceptible. Artificial respiration restored the pulse, and ninety minutes later he regained consciousness.

Easton[17] says: "About 12,000 people die annually in the United States from drowning, gas poisoning, electric shock and so on, according to the New York Police Department, while from 40,000 to 50,000 are rescued from a similar fate by prompt treatment."

The following are the *rules for resuscitation* by the *prone pressure method* as approved by the American Gas Association, American Red Cross, American Telephone and Telegraph Company, Bethlehem Steel Corporation, National Electric Light Association, National Safety Council, United States Army (Office of the Surgeon General, War Department), United States Bureau of Mines, United States Bureau of Standards, United States Navy (Bureau of Medicine and Surgery) and United States Public Health Service.*

* These rules were furnished through the courtesy of Dr. C. K. Drinker, of the Department of Physiology, Harvard University.

"The Prone Pressure Method of Artificial Respiration. Follow These Instructions Even If the Patient Appears Dead.—As soon as possible fee lwith your fingers in the patient's mouth and throat and remove any foreign body (tobacco, false teeth, etc.). If the mouth is tight shut, pay no more attention to it until later. Do not stop to loosen the patient's clothing, but immediately begin actual resuscitation. Every moment of delay is serious. Proceed as follows:

"1. Lay the patient on his belly, one arm extended directly overhead, the other arm bent at elbow and with face turned outward and resting on hand or forearm so that the nose and mouth are free for breathing (Fig. 70).

"2. Kneel, straddling the patient's thighs, with your knees placed at such a distance from the hip bones as will allow you to assume the position shown in Fig. 71.

"Place the palms of the hands on the small of the back with fingers resting on the ribs, the little finger just touching the lowest rib, with the thumb and fingers in a natural position, and the tips of the fingers just out of sight (Fig. 70).

"3. With arms held straight, swing forward slowly so that the weight of your body is gradually brought to bear upon the patient. The shoulder should be directly over the heel of the hand at the end of the forward swing (Fig. 71). Do not bend your elbows. This operation should take about two seconds.

"4. Now immediately swing backward so as to completely remove the pressure (Fig. 72).

"5. After two seconds, swing forward again. Thus repeat deliberately twelve to fifteen times a minute the double movement of compression and release, a complete respiration in four or five seconds.

"6. Continue artificial respiration without interruption until natural breathing is restored, if necessary, four hours or longer, or until a physician declares the patient is dead.

"7. As soon as this artificial respiration has been started and while it is being continued, an assistant should loosen any tight clothing about the patient's neck, chest or waist. *Keep the patient warm.* Do not give any liquids whatever by mouth until the patient is fully conscious.

"8. To avoid strain on the heart when the patient revives, he should be kept lying down and not allowed to stand or sit up. If the doctor has not arrived by the time the patient has revived, he should be given some stimulant, such as one teaspoonful of aromatic spirits of ammonia in a small glass of water, or a hot drink of coffee or tea, etc. The patient should be kept warm.

"9. Resuscitation should be carried on at the nearest possible point to where the patient received his injuries. He should not be moved from this point until he is breathing normally of his own volition and then moved only in a lying position. Should it be necessary, due to extreme weather conditions, etc., to move the patient before he is breathing normally, resuscitation should be carried on during the time that he is being moved.

"10. A brief return of natural respiration is not a certain indication for stopping the resuscitation. Not infrequently the patient, after a temporary recovery of respiration, stops breathing again. The patient must be watched and, if natural breathing stops, artificial respiration should be resumed at once.

"11. In carrying out resuscitation it may be necessary to change the operator. This change must be made without losing the rhythm of respiration. By

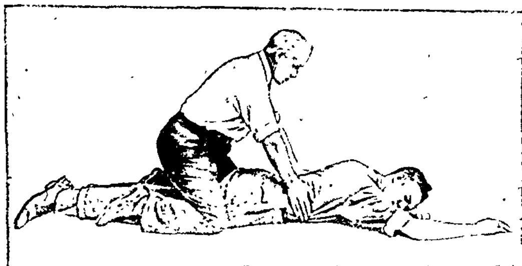


Fig. 70.—Artificial respiration. Position in which patient should always be placed and kept until conscious; also first position for operator starting artificial respiration. (Pamphlet issued by Consolidated Gas Co. of New York.)

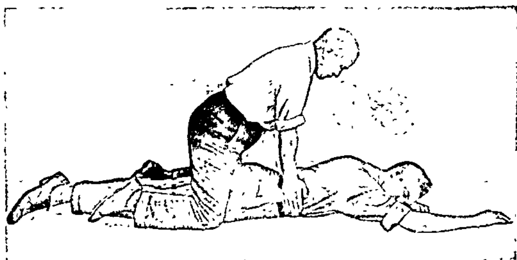


Fig. 71.—Second position of operator giving artificial respiration. (Pamphlet issued by Consolidated Gas Co. of New York.)



Fig. 72.—Third position of operator giving artificial ... issued by C... Gas Co. of New ...

this procedure no confusion results at the time of change of operator and a regular rhythm is kept up.

"General Points to Be Observed in All Cases Requiring Resuscitation.—1. *Take Care of the Patient.*—An unconscious person becomes cold very rapidly, and chilling means a further strain on a vitality already weakened. Experience has shown that the cold to which the victims of gassing, electric shock, or drowning are often carelessly exposed is probably the most important cause of pneumonia, and this disease is the most dangerous aftereffect of all these accidents. As far as possible keep the patient covered while artificial respiration is being given. Use hot pads, hot-water bottles, or hot bricks, but remember that an unconscious man has no way of telling you when he is being burned.

"If it should be necessary to move the patient, keep him lying down, and do not permit him to exert himself.

"2. *Medicines and Medical Help.*—Never give an unconscious man anything to drink. It may choke him. Medical science knows no drug which of itself will start breathing in a patient whose breathing has ceased.

"Continue artificial respiration for at least four hours in all cases. Breathing has returned after eight hours in a case of electric shock, but in such instances the patient will give some evidence of recovery which will cause continued effort on the part of his rescuers. Medical men have sometimes been mistaken in declaring patients dead and employees of public utility companies have succeeded with resuscitation after such declarations. Therefore, the ordinary and general tests for death should not be accepted, and any doctor should make several very careful and final examinations and be sure specific evidence is present before pronouncing the patient dead.

"Electric Shock.—*Breaking the Contact.*—The victim must be freed from the contact as promptly as possible. Use a dry stick, dry rope, dry coat, or other nonconductor. Use of your own hands without protection is dangerous and may add another victim to the accident.

"*The Action of the Electric Current.*—In electric shock the current may pass through the breathing center at the base of the brain and cause this center to stop sending out the nervous impulses which act upon the muscles responsible for breathing. As a consequence, breathing stops abruptly. If the shock has not been severe, after a time the breathing center recovers and resumes the vitally necessary duty of sending impulses to the muscles of breathing. In such cases, the immediate use of the prone pressure method substitutes this artificial breathing for the natural respiration of the patient. As has been pointed out, the current may so paralyze the breathing center as to require eight hours for recovery, and the prone method must be used unceasingly throughout this entire time. If, during prolonged artificial respiration, the body can be placed on a door or other flat surface so that the head and chest are 6 or 8 inches lower than the feet, the flow of blood to the heart is promoted and a better chance given for recovery.

"Victims of electric shock of this sort are unconscious, but in them the heart and blood circulation continue. Their treatment demands artificial respiration with the greatest possible promptness. The method for giving this and the general measures for the care of such patients have been given.

"If the electric current affects the heart it produces a condition called fibrillation in which the heart resembles a bag of quivering jelly instead of

the regular pumping organ which maintains life. Under these circumstances the heart suddenly ceases to pump blood. Many cases of electric shock escape this heart effect and even an experienced examiner requires time to assure himself it has occurred. Consequently it is the duty of those first reaching the shocked person to give artificial respiration by the prone method at once and to allow time and medical examination to determine whether the heart has stopped.

"*Use of Inhalation in Electric Shock.*—Shocked patients who have resumed breathing often suffer later periods of failure of breathing. They must be watched closely for hours after the accident. The use of the inhalation treatment should render such failures of breathing less likely to occur.

"Whenever possible obtain the assistance of a gas company emergency crew to aid you with inhalation in these cases, but remember that the measure which saves life is the prone pressure method of artificial respiration."

The method of artificial respiration developed by Holger Nielsen and endorsed by Prof. Krogh, of Copenhagen, is said to be 41 per cent more efficient than the Schaefer method. The method is described by McHugh[18] in the following words:

"In applying this Nielsen method to a patient, first remove his clothing or any parts of it, at least, which will tend to hamper the free movement of the patient's shoulders and lungs. Lay him face downward on a flat, hard surface. Should this surface be sloping, be sure that the patient's head is at the lowest point. Arrange his arms as shown in the illustration, bent and folded under his forehead, not so much to protect his face from bruising but to prevent any twist of the neck which would interfere with breathing. A handkerchief should be placed beneath the patient's mouth and nose to prevent the intake of dust. When patient and operator are in position, the patient's back must be slapped sharply between the shoulder blades several times to cause the tongue to fall forward out of the mouth. If this is unsuccessful, the operator draws it forward with his fingers.

"Artificial respiration is then administered by the operator swinging his body forward, throwing only his weight, but no muscular force, onto the patient's shoulders. The move- [illegible] pressure is progressive. The pressure is contin[illegible] until the operator's [illegible] position of the patient's head or torso. This position is held while the count is continued up to eight. The operator then assumes his original position and repeats the routine, the [illegible] There should be no [illegible] east

Thompson[19] says that mechanical methods of resuscitation (mechanical resuscitators using inflation alternating with suction deflation) are markedly superior to manual methods. Tingley[20] recommends that Schaefer's method of artificial respiration be carried out at the rate of 60 times per minute and Silvester's method at the rate of 45 times per minute.

Viswanathan's[21] method of artificial respiration is performed by standing at the head of the bed or operating table. The palms of the hands are placed on the lower part of the patient's chest, the middle fingers on the anterior axillary lines, the fingers hooked beneath the inferior margins of the lower ribs. By gentle traction on these lower ribs, the chest can be made to assume the raised position of inspiration; the pull is made in an upward and outward direction, and lasts about three seconds. The pull is then released and the chest is pressed gently downward and inward: at the same time the fingers,

now extended, press upon the upper abdomen. The cycle of pulling and pushing is repeated 12 to 15 times a minute. This method is thought to be



Fig. 73.—The Eve "rocking method" of resuscitation. (Copyright by Surgeon Commander G. H. Gibbens, R N.V.R., Fairlawn, Sidmouth, Devon, England. Eve, F. C.: J. A. M. A. 124: 964, 1944.)

very much more efficient from the standpoint of gaseous exchange in the lungs than the Schaefer or Silvester methods.

The Eve[22] "rocking method" for resuscitation of the drowned, which is worked by gravity and is independent of muscular tone, has been adopted preferentially in the British Navy. A pair of wooden blocks is placed on an ordinary stretcher to keep it from slipping. The stretcher is placed on a trestle 34 inches high or a loop of rope slung from hammock hooks (Fig. 73). Schaefer's method is used promptly and until rocking can actually begin. The patient is laid face downward and the ankles and wrists are lashed to the handles of the stretcher. The first head-down tilt of 45 degrees is maintained till no more water drains from stomach or lungs. After a few minutes a tilt of 30 degrees each way (ten times a minute) will be enough to ventilate the lungs. The advantages are that untrained operators can work it instead of the relays of skilled operators needed by manual methods. It cannot injure ribs or viscera and is independent of muscular tone in blood vessels or dia-

phragm, in which respect unfortunately Schaefer's method fails. Wet clothes can be removed during rocking and warmth applied."[23]

Ross[24] studied reports of 3352 cases of artificial respiration. Revival resulted in 153 cases in which a mechanical resuscitator was used and in 58 cases in which the Schaefer prone pressure method was used. "No instance of revival was reported in which more than fifteen minutes elapsed between the cessation of breathing and the start of artificial respiration."

While the manual method of artificial respiration is thought to be the best, yet, if the persons giving it become too tired, an apparatus for the prolonged administration of artificial respiration may be employed. Of these the one described by Drinker and McKhann[25] is to be recommended. Birnbaum and Thompson,[26] after numerous experiments on animals, conclude: "1. In advanced asphyxia, after cessation of respiration, rhythmic inflation and suction of oxygen or oxygen-carbon dioxide at safe pressures is definitely superior to manual artificial respiration or rhythmic inflation. 2. Rhythmic inflation and suction regularly produce resuscitation even with inert (asphyxiating) gases."[27] Good results have also been obtained by the breathing of carbon dioxide.

For a complete discussion of resuscitation, reference should be made to the articles by Henderson[28] and Mjinlieff.[29] Jellinck[30] calls attention to deficiencies in the usual methods of resuscitation, namely, to the fact that there is frequently neglect to pull the tongue of the victim forward so as to permit a free passage of air, and to the fact that by the compression of the thorax, which is the principle of the usual methods of resuscitation, the negative intrathoracic pressure, which is so important for the cooperation of lung and heart and also for the lung itself, is reduced or even nullified. The fact that the compression of the thorax sometimes produces results does not appear to the author as a valid argument against the danger inherent in this method. In discussing the first point of his criticism, that is, the failure to insure a free passage of air, he shows that some of the methods suggested for this are not suited for emergencies. He suggests a new method. He advises that the second and third fingers of the right or left hand of the victim be brought into the mouth so that their terminal phalanges press the tongue against the lower teeth and that at the same time the fingers be pushed completely into the mouth. In order to keep them in this position, the elbow has to be given support by being tied up. Not only respiratory experiment but also roentgenoscopic study reveals that this automatic fixation of the tongue leaves the air passages unhindered. In order to avoid the dangers involved in the compression or traction of the thorax the author suggests the following method: The victim is lying horizontally on his back. A folded cloth, some paper or some straw is placed under him in the region of the upper angles of the scapulas, thereby producing a free space between the shoulders and the surface the patient is lying on. Then the tongue fixation is done in the manner described. Artificial respiration is carried out by grasping each shoulder with one hand in such a manner that the fingers rest on the external surface of the upper end of the arm and the thumb on the acromial termination of the clavicle With a quick pressure the shoulders are pressed downward, and after a second the pressure is released just as quickly. The same procedure is repeated after intervals of from one to two seconds. In discussing the effect on the thorax, the author points out that roentgenoscopic study reveals that the described manipulation of the shoulders results in an extension of all three diameters of the thorax. Tests of the pressure conditions and manometric tests disclose the suction produced by the method; in fact, all tests prove that this new technic of artificial respiration produces enlargement of the thorax and active inspiration.

Drugs in Electric Shock.—Drinker[31] says: "At the present time there is no substance which can be given by injection which benefits the breathing significantly. Caffeine and sodium benzoate intravenously may be useful but has no specific potency. . . . There is no practical procedure which affects the fibrillating heart muscle, and an intracardiac injection of epinephrine can be relied on to do but one thing, namely, make fibrillation worse, so that

any chance of spontaneous shift to normal pulsation is lost." Pearl[32] says: "The use of stimulating injections is not advised. Lobeline is dangerous and may even cause the death of the patient. Oxygen inhalations may act as a respiratory depressant. Carbogen (7 per cent carbon dioxide in oxygen) combined with artificial respiration is of definite value if the patient has begun to breathe."

Treatment of Burns.—For small first and second degree burns an application of petrolatum, "sulfathiazole ointment" or even just a piece of sterile gauze will suffice. The larger burns are best treated by the Koch pressure dressing method. (See the chapter on Burns.) It is often wise to administer tetanus antitoxin.

Wells[33] makes the following recommendation: "Third degree electric burns are always sharply circumscribed, and the line of demarcation between the necrosed and normal tissue is as clear and distinct as it is in a case of gas bacillus infection. If the eschar is treated expectantly, it is certain that a deep slough must separate completely before the wound can heal. On the other hand, the eschar can be often resected *en bloc* and the resultant wound closed by primary suture or immediate skin graft, with great saving of suffering on the part of the patient, a material shortening of the period of immediate disability, and ultimate conservation of the functional capacity of the injured part."

After-Treatment.—Pearl[4] says: "When a worker receives a shock from which he recovers within a few minutes, it is the custom of employers to allow him to continue with his activities. The complications and sequelae noted should be sufficient warning, however, that [illegible]

"The victim may be incapacitated for long periods of time as the result of his injury. Especially when psychic disturbances are concerned, one is tempted to brand such patients as malingerers or hysteroneurotic persons. It is often difficult to judge just how much is due to the effect of the current on the body and how much to an attempt on the part of the patient to obtain prolonged compensation. The current is an agent which may produce profound functional changes in the central nervous system, and thus offer difficulty in properly evaluating symptoms which might be ascribed to it."

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CHAPTER VII

CIRCULATORY DISTURBANCES AND GANGRENE

VARICOSE VEINS AND VARICOSE ULCERS

Varicose veins have been defined as veins having permanent dilatation due to changes in their walls (Matas). Varices (varicose veins) are of four types:[1] (1) the isolated saccular varix; (2) the tortuous varix; (3) the solitary, dilated and hypertrophied but otherwise normal piece of vein interposed between the varices, and (4) fine cutaneous dilatations. In addition to the changes in the walls themselves, varicose veins are characterized by having incompetent valves. Varicose veins often occur in persons whose occupations require them to be long hours on their feet, e. g., motormen and policemen.

Adams[2] says: "1. The erect posture has resulted in venous pressure in the legs which may reach 100 mm. of mercury, depending on the height of the patient, a fact borne out by direct readings of venous pressure. This is a pure gravity effect. 2. The erect posture [illegible] varicose veins." Barrow[3] says: "In varicose veins, venous valves become incompetent and assist in venous return only with difficulty. This interference with the normal mechanism of venous return is reflected by increased venous pressure. This increased venous pressure is not of great significance so long as there is an alternate normal route (deep and communicating veins) for the return of blood from the capillaries to the heart. When no such normal route persists, increased venous pressure provokes increased capillary pressure, which, in turn, is followed by increased interstitial fluid and interference with the exchange of gases and metabolites between tissue cell and capillary blood stream. Lasting cure of patients with varicose veins has been experienced only when physiologic abnormalities have been corrected or compensated. Obliteration of the superficial varices alone has rarely proved of more than temporary benefit to patients with incompetence of large venous trunks."[4] Eger and Casper[5] dissected 38 adult cadavers to determine the respective number of valves in the external iliac and femoral veins to the level of the orifice of the great saphenous veins. There was a total absence of valves on one or both sides in 36.8 per cent. Mayerson et al.[6] studied venous pressures of patients with varicose veins and say: "No differences were observed in the height of the venous pressure in 'normal' and in varicosed saphenous veins of standing patients. In both types of veins the pressures were usually only slightly higher than the hydrostatic pressure. The antecubital and saphenous venous pressures of patients with varicose veins were found to be significantly *higher than 'normal'* [illegible] position is assumed.

Varicose veins of the lower extremity are apparent *when the patient is* standing and disappear when he is lying down. The internal saphenous vein and its branches are oftenest affected. Prioleau[7] reports an interesting case of extensive varicosities of the leg originating from the gluteal vein. Berntsen[1] stresses the importance of heredity and believes that varices occur more frequently in women than in men.

Lake and his associates,[8] in a study of department store employees found, among other facts, that "women showed a much higher incidence of varicose

veins than did men employed at the same occupations. This difference held true when the factor of pregnancy was removed from the data. Women who had been pregnant showed a higher incidence of varicose veins than women who had never been pregnant. Varicose veins were extremely common among the working men of this series. Women who stood or walked showed a much higher incidence of varicose veins than women who sat at their work."

As much as 500 cc. of blood may accumulate in varicose veins when the patient is walking or standing. This pooling of blood is doubtless related to the varicose veins.[9] Zimmerman and Rattner[10] have pointed out the value of infra-red photographs for the visualization of varicose veins which are not visible to the eye.[11]

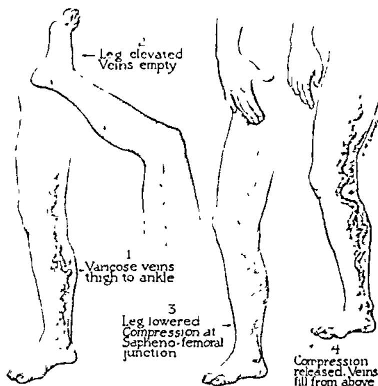


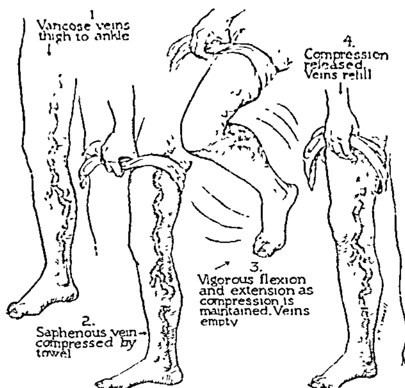
Fig. 74.—Trendelenburg test. The leg is first elevated to empty the vein, and constriction is applied. Enough pressure is exerted to collapse only the superficial veins. The patient then stands up while the pressure is maintained. Note the collapse of the veins below the knee. The fourth sketch shows the leg immediately after the pressure of the hand has been released. Note the sudden filling of the veins from above. (de Takáts, G., in Christopher, F.: Textbook of Surgery, ed. 4, Philadelphia, W. B. Saunders Co., 1945.)

Varicose veins occasionally may cause the patient considerable pain or a *sensation of heaviness*. On the other hand, very large varicosities may be absolutely symptomless. Moderate traumatism frequently will rupture a varicose vein, and alarming *hemorrhage* will occur. Such hemorrhages, of course, are readily controlled by direct pressure on the bleeding point and by elevation of the extremity. The writer has seen a case of an old blind man, a derelict in the New York slums, who upon arrival of the ambulance was found dead surrounded by a pool of blood from a ruptured varicose vein. The simplest type of first aid (elevation and direct pressure) would have been far more valuable than the frantic effort at procuring a doctor.

Varicose veins of the lower extremities frequently are the site of phlebitis, which requires the appropriate treatment of rest and elevation. These patients seem to recover much more rapidly with hot fomentations than with the application of cold.

A patient presenting himself for examination for varicose veins should be subjected to tests for the competency of the valves.

Trendelenburg Test (Fig. 74).—With the patient lying supine, the leg is extended straight upward so that the blood may flow out of it. A constrictor is then applied high on the thigh and tightly enough only to collapse the superficial veins, or direct firm pressure is applied at the saphenous opening to block the saphenous vein. The patient then stands up with the constrictor



PERTHES TEST

still in place or with the pressure on the opening maintained. If the veins in the calf remain collapsed, one may conclude that the reflux of venous blood occurs only from above, that is, through the saphenofemoral junction, and not from the deep veins. If, however, the veins of the calf fill quickly in spite of compression on the saphenous vein, this is evidence that the communicating valves to the deep veins are incompetent. In such cases, more treatment is required, and recurrence is more likely. Adams[2] says:

"We have felt that the Trendelenburg test, as usually performed, is not a satisfactory test of valvular competence, inasmuch as it takes into consideration standing pressures only. We have frequently observed patients whose valves were competent to standing pressures and so exhibited a negative Trendelenburg, yet whose valves were incompetent

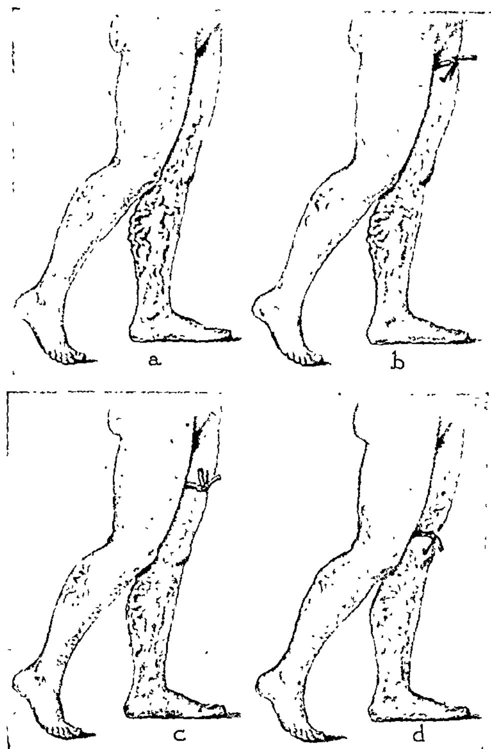
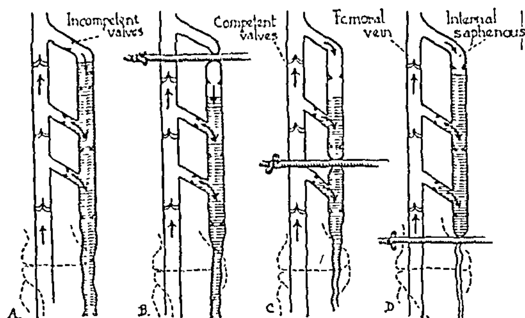


Fig. 76.—Drawings illustrating the performance of the comparative tourniquet test for determining the competency of the valves of the veins communicating between the deep and the superficial systems and the patency of the deep veins of the leg. "The patient walks

the veins is noted. If the deep and communicating veins of the thigh are patent, there is diminished prominence of the veins of the calf when the patient walks with the tourniquet applied. If the valves of the communicating veins are incompetent, when the patient walks

to the added pressure of straining and promptly exhibited a positive Trendelenburg when this factor was introduced. Consequently, we speak of a valve as being relatively competent when it withstands ordinary pressures but permits reverse flow under the added effect of strain. If the fingers of the palpating hand of the examiner be placed over the saphenous opening of the patient in the standing position, back flow in the incompetent cases is readily detected as a palpable venous thrill when the patient coughs or strains."[12]



Valves of Communicating Veins, as well as of the Internal Saphenous Vein, Are Incompetent

Fig. 77.—The physiology involved in the comparative tourniquet test on the left leg of a patient when the valves of the communicating veins as well as of the internal saphenous vein are incompetent. When the tourniquet is high, it stops retrograde flow through the internal saphenous vein; but there is an abnormal flow from the deep to the superficial systems below the tourniquet through the communicating veins. Only when the tourniquet is below the lowest communicating vein with incompetent valves, as in *D*, is there collapse of the varicosities. (Mahorner, H. R., and Ochsner, A.: Ann. Surg. 107: 927, 1938.)

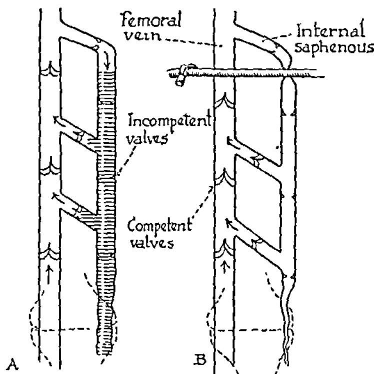
Perthes Test (Fig. 75).—This test gives information as to the patency of the deep veins. The saphenous trunk is constricted with a tourniquet, and

through the incompetent communicating veins from the femoral to the long saphenous veins. When the tourniquet is below the lowest communicating vein of the thigh in which the valves are incompetent (*d*), the varicosities of the calf collapse or disappear. When valves of the communicating veins are incompetent, high ligation alone is not sufficient,

ment when the tourniquet is around lower levels, then the valves of the communicating veins are competent, and high ligation and section of the saphenous vein are sufficient to interrupt the retrograde flow from the deep system. In *b* slight improvement (diminution in prominence) is shown over that indicated in *a* in a case in which the blood spills through the communicating veins below the level of the tourniquet. In *c* more improvement in the veins of the calf is shown, and in *d* the greatest improvement appears. If the improvement shown in *b* were complete, the test would indicate competency of the valves of the communicating veins of the thigh but incompetency of the valves of the internal saphenous veins." (Mahorner, H. R., and Ochsner, A.: Arch. Surg. 33: 479, 1936.)

vigorous muscular exercise is carried out. If the deep veins are patent or if there is not an increased pressure in them with standing, the exercise will aspirate the blood from the superficial veins, and they will be seen to collapse. If the superficial veins do not collapse, this is evidence that the deep veins are not patent or that their pressure is greater than normal. If the deep veins are not patent, caution must be observed in obliterating the superficial ones.

Mahorner-Ochsner Test (Figs. 76–78).—Mahorner and Ochsner[13] believe that their comparative tourniquet test is more accurate than the Trendelenburg test in demonstrating any leak through the communicating valves. The test and its interpretation may be understood by a study of figures 76–78.



Valves of Internal Saphenous Vein Incompetent

Fig. 78.—Physiology involved in the right leg of a patient. When the tourniquet is placed high there is complete collapse of the varicosities, since the valves of the communicating [illegible] ...henous [illegible] Ochs- [illegible]

The Percussion Test (Schwartz).—*This test is made with the patient standing* before the examiner. McCallig and Heyerdale[12] consider this test as probably the most practicable to demonstrate incompetence of the venous system. They describe it as follows:

> "The fingers of one hand are placed over the great saphenous vein, usually at the fossa [illegible] in the leg below. [illegible]
>
> If the fingers at the fossa pick up a definite and strong impulse, incompetent valves and a dilated main saphenous trunk are strongly to be suspected. Proof, however, is established by a reversal of the procedure. If percussion of the vein at the fossa or in the upper portion

of the thigh produces an impulse which travels downward to the fingers below, and can be definitely felt, we know that the valves are incompetent and that the vein does not, and never will, perform its normal function. For such an impulse cannot travel distally in the vein if the valves are competent (Fig. 79.)"

Test for Deep Venous Circulation.—McCallig and Heyerdale[12] believe that the only conclusive test for demonstrating an obstruction in the deep venous circulation is the following:

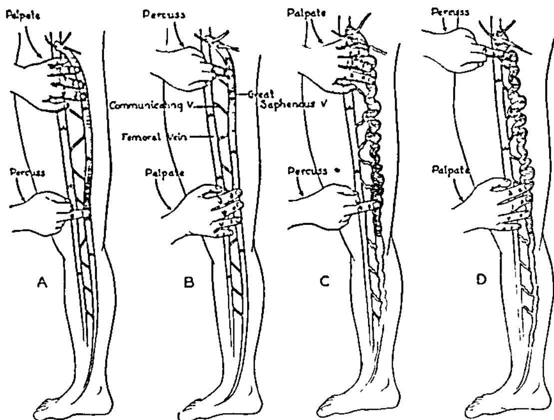


Fig. 79.—Percussion test (Schwartz). Testing for an incompetent greater saphenous system: *A* and *B*, a normal competent vein; intact valves prevent downward passage of the impulse; *C* and *D*, procedure used in detecting incompetent veins in which the valves do not impede the free passage of a strong impulse in both directions. (McCallig, J. J., and Heyerdale, W. W.: J. A. M. A. 115: 97, 1940)

or diminished, If the flow through the superficial venous system is a compensatory one, the constriction ... the bandage will result in acute severe discomfort, because those

Location of "Blowouts."—If, with the patient lying supine and the leg elevated, a tourniquet is applied and then the veins do not fill when he stands (Trendelenburg test), the absence of "blowouts" may be assumed. Lyall[15] says: "If during the test described the veins fill rapidly while the

tourniquet is in place it is presumed that there is a blowout present. The level of the early influx of blood will give a clue to its location. To locate blowouts Pratt devised the following: 'An Ace bandage is applied from the toes to the groin and a tourniquet placed on the thigh above this area. As the bandage is removed, a sudden protrusion of a collection of veins shows the point of incompetence. A second Ace bandage, which may be wrapped from above down, exposes only a small area at a time and is helpful' (Fig. 81). This is easily and quickly done. I believe, however, that the lower Ace bandage keeps the varices only partly empty, that, as it is unrolled, blood fills the visible portion of vein and that the blood may have come from below and

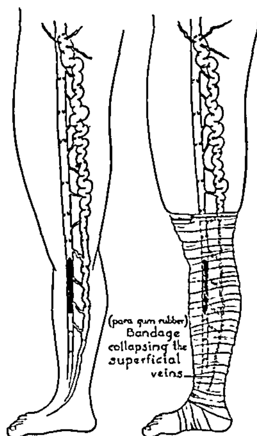
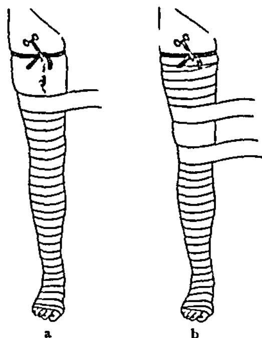


Fig. 80.—Test for obstruction in the deep venous circulation. When such a condition is present, severe pain results from the blockage of venous return. (McCallig, J. J., and Heyerdale, W. W.: J. A. M. A. 115: 97, 1940.)

not necessarily via a blowout. To locate these blowouts more exactly and to prevent the upward reflux from giving false positive tests for blowouts, I make repeated application of the tourniquet at different levels, emptying the veins by elevating the leg between each application. The presence of a suspected blowout in any vein segment can be readily detected by using two tourniquets (Fig. 82). The vein is emptied and a tourniquet is applied on either side of the suspected site. If the isolated segment fills there is a blowout somewhere between the constrictions. By repeating the procedure, shifting the tourniquets, the blowout can be accurately located and marked."

The Injection Treatment of Varicose Veins.—Since the publication of the first edition of this book, almost innumerable contributions to the surgical

literature have shown that the injection of sclerosing solutions in the treatment of varicose veins has been universally accepted. The method is safer and easier than surgical excision. The combination of higher ligation of the great saphenous vein and subsequent injection, is a distinct advance in the treatment of varicose veins. The safety of the injection treatment may be judged by the finding of only 7 deaths in 53,000 collected cases.[16] Pennoyer[17] found 4 authentic instances of fatal pulmonary embolism in 400,000 reported injections, and Kilbourne[18] reported 20,000 injections without a fatality. Westerborg[19] found 11 deaths from pulmonary embolism following injections for varicose veins in 30,000 cases. There were also 11 severe but nonfatal



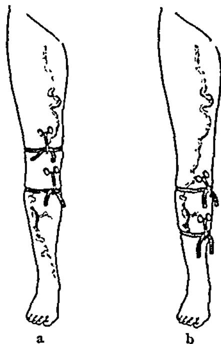


Fig. 81. Fig. 82.

Fig. 81.—a and b, Method of locating multiple blowouts using a tourniquet and two elastic bandages (after Pratt).

Fig. 82.—a, The leg has been elevated, thus emptying the veins and a segment of vein isolated between tourniquets. The segment has remained empty in the erect position, indicating an *absence* of blowouts in this segment. b, Test repeated with tourniquets reapplied lower down. Segment has rapidly filled, indicating presence of blowout. Note: Veins below lower tourniquet remain empty, indicating absence of blowouts. (Lyall, D.: Surg., Gynec. & Obst. 82: 332, 1946.)

cases. All the subjects were middle aged and were confined to bed on account of pain. In 1200 cases of injection plus ligation of the saphenous vein, there were 4 deaths from pulmonary embolism. The embolism may have been independent of the injection in some of the cases. Vaughn and Lees[20] review 44 reported cases of fatal pulmonary embolism following the injection treatment of varicose veins and conclude:

"The injection treatment of varicose veins is not free from complications, which may even be fatal. Injection of too large amounts of sclerosing solution, as was the vogue in the earlier days of treatment of varicose veins, is dangerous. It is noted from the accompanying tables that 40 to 90 cc. of solution was used in some of the fatal cases. In our opinion, no more than 10 cc. of solution should be injected at any one visit. Injection in the presence of thrombophlebitis is a potential source of an embolus. . . . Bedridden patients

should not be injected. It is important to keep patients ambulatory following the injection treatment of varicose veins."[22]

Kilbourne studied 20 reported fatalities after injection and concluded that most of them were due to bacteremia caused by contamination at the time of injection or by the lighting up of an old thrombophlebitis. These factors should be eliminated with good technic and the avoidance of unfavorable cases.

Johnson,[22] in his excellent review, says:

"The reasons for the relative safety of the injection method are explained by histologic and pathologic findings. When any of the common operative procedures for treating varicose veins are carried out, blood clots are left in close proximity to open veins and ligated veins from thrombi in their stumps. These are fairly firm clots but they are not dependent on injury to intima for their formation. In postoperative thrombophlebitis, simple stagnation of blood is probably the most important factor. Hence the thrombus is not densely adherent to the intima and therefore at times is loosened into the blood stream. In the case of bacterial thrombophlebitis this danger is much greater. The thrombus is formed by the action of the bacteria on the stagnant blood stream and upon the intima. After the formation of this thrombus, however, the bacterial action is to break down and liquefy it, thus replacing the original and rather firm clot with a mass of small thrombi, loosely adherent in a semifluid state. This furnishes the ideal basis for embolism.

"In the case of thrombosis of a vein following the injection of some highly irritating substance, the thrombus forms as a result of severe injury to the intima. The intimal cells first swell and often rupture; the thrombosis is laid down upon this injured area and becomes densely adherent to it. Instead of subsequent liquefaction, the thrombus quickly undergoes organization, the fibroblasts growing directly from the vein wall into the clot. Thus there is less danger of emboli breaking off and entering the blood stream."

Surgical excision gives a mortality of 0.4 to 1 per cent.[29] The recurrence rate following combined ligation and injection varies from 1 per cent[23] to 23 per cent,[24] although recanalization of the thrombosed veins is probably the rule. In injection without ligation the recurrence rate is much higher. Ligation is not necessary if there is no incompetence of the veins. Under these circumstances, injection treatment of the local varicosities is advisable.

McPheeters[25] says: "When there are complications in the lower leg, as ulcers and eczemas, secondary to the presence of the varicose veins, most workers prefer to use the supportive therapy until the case is under control and then ligate and inject the solution as in any other case. With this I fully agree."

Contraindications to ligation and injection include advanced age, pregnancy, debilitating disease, severe impairment of the arterial blood supply to the part, previous or coexistent phlebitis, and pelvic tumors or other mechanical obstruction to the venous flow. Greene and Greene[26] report a fatal thyroid crisis occurring a few hours after the injection of a varicose vein.

The Varicose Vein Committee of the American Medical Association (G. de Takáts, chairman) at its exhibit on varicose veins at the 1930 meeting of the American Medical Association gave the following as contraindications to the injection treatment of varicose veins:

"(A) Systemic diseases:

"*Hyperthyroidism* (requires immediate arrest of the disease; precedes in importance any other intervention).

"*Active tuberculosis:* Subfebrile patients with slight pulmonary changes may flare up after the use of tissue irritants.

"*Acute colds, infections:* These conditions may be seen in office patients and may be overlooked or neglected.

"(B) Local conditions:

"1. *Impairment of arterial circulation.*

"2. *Lack of patency in the deep veins. Test of Perthes.*

"3. *Thrombophlebitic edema* with a history of deep phlebitis.

"4. *Acute or subsiding superficial phlebitis.* Slumbering infection may flare up."

Harkins and Schug[27] say: "In general, injection alone was reserved for cases with (1) no palpable superficial veins above the knee and (2) a normal

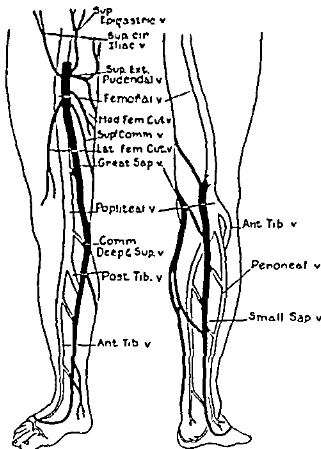


Fig. 83.—Communication between the deep and the superficial venous system of the lower extremity. The diagram also shows the accessory veins and the branches as they sometimes empty into the saphenous vein, requiring separate ligations. (Modified from L. K. Ferguson. Sarma, P. J.: S. Clin. North America 18: 129, 1938.)

Trendelenburg reaction." In their series of about 80 patients with varicose veins seen in 1940, "only about 5 were advised to have injection alone."

McAusland[28] says: "The tendency to develop varices is not cured by injection; all underlying causes must be found and where possible eliminated; the fundamental causes of ulceration are 'water-logging' by gravity and consequent atonicity; and for some months, and often permanently, leg supports must be worn in order to support the circulation and assist the tissues in regaining normal tone. More attention to these details and careful combination of all means of treating varices will reduce the incidence of recurrence."[30]

Ligation of the Great Saphenous Vein.—De Takáts[31] emphasizes that *the effectiveness of the injection treatment of varicose veins has been greatly enhanced by high ligation of the saphenous vein* (at the femorosaphenous junction).

"This operation is obviously not indicated in every patient with, and treated for, varicose veins. If the greater saphenous vein is dilated only below the knee, and the course of the vein is not visible or palpable above the knee, when full weight is exerted on the extremity, one must assume that the saphenous valves above the knees are competent. In such patients the Trendelenburg test does not reveal insufficient valves in the long saphenous vein. The ligation here would be unnecessary (Fig. 84, *a*). On the other hand, it is possible for all valves to be incompetent, both in the saphenous and in the communicating veins. The Trendelenburg test is doubly positive. The varicose veins fill up suddenly from above in spite of saphenous compression, but a further increase in size is observed when the compression is released. The ligature of the vein on the thigh would only partially relieve back pressure (Fig. 84, *b*). It would only slightly diminish venous pressure and might even favor the dilation of other tributaries.

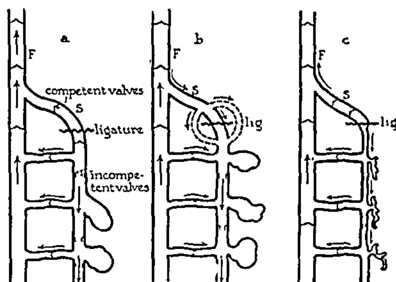


Fig. 84.—Diagram showing the effects of ligation of the long saphenous vein. *a*, When [illegible]

"The indication for saphenous ligature is clearly given when, after elevation of the limb [illegible]

sudden diminution of venous pressure, as reported elsewhere. It should, however, be placed under the protection of the last competent valve; otherwise the same complication as illustrated in Fig. 84, *b*, will develop (Fig. 84, *c*)."

The advantage in ligation lies in creating a barrier which prevents ascending thrombosis; it is impossible to predict the length of the thrombus following an injection (de Takáts).

In 1933 de Takáts wrote: "On the basis of 200 ambulatory vein ligations combined with the injection treatment for varicose veins, we think that this procedure has a definite place in the treatment for this condition. The high saphenous ligation protects the treated veins from fluctuations of abdominal pressure and hydrostatic pressure thus preventing canalization of the

thrombi. It also reduces the necessary number of injections and places the occluding ligature close to the saphenofemoral junction. By insisting on a short proximal stump and on ambulatory management, we can report no embolism in the entire series. The complications reported in this series all seem avoidable with growing experience. The end-results of the operation combined with injections show a far smaller percentage of recurrences than those obtained with any other procedure in the treatment for varicose veins." He sums up his indications and contraindications for ligation of the saphenous vein as follows: The operation is indicated "(1) in valvular incompetence of the long saphenous vein above the lower third of the thigh, (2) in valvular incompetence of the anastomotic branches, if they resist injection treatment and (3) in ascending thrombophlebitis of the saphenous vein.

"The operation is contraindicated: (1) when the vein is not involved above the knee, (2) when there are multiple incompetent valves in the communicating branches which cannot all be ligated and (3) when there is evidence of insufficient deep venous return owing to an old deep phlebitis or a deep valvular insufficiency."

De Takáts'[31] technic for ligation of the saphenous vein is given herewith in his own words:

"*Technic of Ambulatory Vein Ligation.*—It would hardly seem necessary to describe a simple vein ligation in detail. Nevertheless, there are a few minor details that are significant because the operation is performed on ambulatory patients. The operations were done in a sterile operating room either at the hospital or in a perfectly equipped operating room of the surgical dispensary, with all necessary precautions such as masks and mouthpieces covering the nose. In the standing position the course of the vein is marked out with a 2 per cent solution of brilliant green. The skin is shaved dry just before the operation and prepared with ether, iodine and alcohol. The line of incision in high saphenous ligations runs about a handwidth distally and parallel to Poupart's ligament and should start mesially to the palpable femoral artery. Naturally, if the vein is palpable at this level, a shorter incision of from 3 to 4 cm. is sufficient. Generally we prefer transverse incisions, because thus some of the accessory saphenous branches are caught and tied. However, if a longer segment of vein should be excised with its insufficient anastomotic branch, a longitudinal incision is more useful.

"The line of incision is infiltrated with 0.5 per cent procaine hydrochloride with 3 drops of 1:1000 epinephrine to each ounce. Only a superficial subcutaneous infiltration is made, and repeated aspirations are made for blood. Because of the vicinity of the large vein, care must be taken not to inject any procaine hydrochloride intravenously. In one patient, as reported in a previous article, only a few drops of procaine hydrochloride were sufficient to produce pallor, tachycardia and numbness of the lips and fingers. The toxic effects wore off in a few minutes, but illustrate the necessity of extreme care in this region to avoid intravenous injection.

"After waiting about five minutes for a complete anesthesia, incision is made through the skin and subcutaneous fat. In some patients a strong tortuous anterior branch lies immediately under the skin and needs no further exposure. This, however, may not be the main trunk, but a collateral from the superficial epigastric, overcoming a previous iliac block. At this high level (three fingerbreadths below Poupart's ligament) the main trunk lies below the superficial fascia and has to be exposed at a depth of from 2 to 4 cm., or sometimes even more. When the main vein is exposed, a perivenous injection is made on both sides [illegible]
A [illegible]
ur [illegible]
segment of vein is well lifted up to detect communicating branches from the deep veins, which should also be carefully tied as they may produce a profuse hemorrhage. It is important to place the proximal ligature as close to the femoral junction as possible [illegible]
very [illegible]
stum [illegible]

"The segment of vein is then removed, and it is used for bacteriologic study. Before the wound is closed the patient is asked to cough a few times to catch, if necessary, additional bleeders. No sutures are placed in the subcutaneous fat, and the skin is closed with interrupted dermal sutures. The skin around the incision is now painted with a mastic solution, and the gauze is stuck to the skin with the solution. In ambulatory patients who perspire freely, sweat and dirt cannot be kept away from the incision with the usual adhesive tape bandage. This solution, which one of us has used exclusively since 1914 in all aseptic operations, keeps the skin around the incision dry and protected. We strongly emphasize its use here, particularly in dispensary patients, who sometimes return with soiled and slipped dressings.

"The patients return for inspection in forty-eight hours, and the stitches are removed on the eighth day. They are asked to stay away from work for the first two days and may

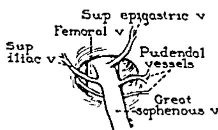


Fig 85

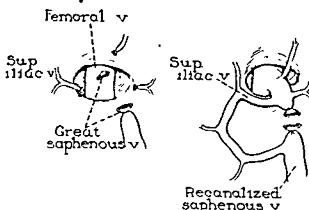


Fig. 86.

Fig. 85.—Normal anatomical relationships of the great saphenous vein and its tributaries a the fossa ovalis.

[illegible]

723, 1940.)

return to work after the first inspection. They should not stay in bed during the day for any time."

Mahorner and Ochsner[32] advise an incision which "begins at Poupart's ligament and 2.5 cm. mesial to the line of the femoral artery. The latter landmark is appreciated by palpating the pulsating artery as it passes under the middle of Poupart's ligament. The incision continues for about 5 cm. straight downward and slightly inward, diverging from the line of the artery."

Edwards[33] made a large number of dissections of the great saphenous vein and concluded: "The site of the saphenofemoral junction does not vary greatly in different individuals. Its average location may be found at a spot 3.9 centimeters lateral to and 1.7 [illegible] prob- [illegible] ble it [illegible] level of the pubic tubercle and 1 centimeter medial to pulsation of femoral artery."

Infiltration anesthesia is usually satisfactory. For regional block anesthesia the method of Seldon may be employed.

The author ligates the saphenous vein and its tributaries with no. 3 braided silk. He considers it of *utmost importance always to transfix the cut ends of the veins as well as to*

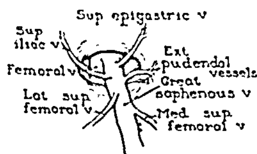


Fig. 87.



Fig. 88.

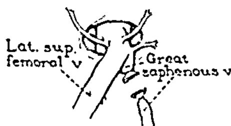


Fig. 89.

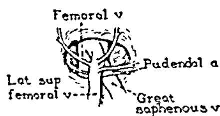


Fig. 90.

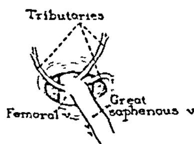


Fig. 91.

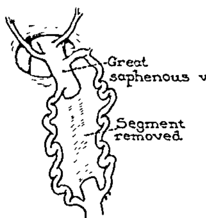


Fig. 92.

Fig. 87.—Great saphenous vein at fossa ovalis showing lateral and medial superficial femoral veins.

Fig. 88.—Dilated lateral superficial femoral vein ligated and incompetent great saphenous vein overlooked.

Fig. 89.—Improper ligation of great saphenous vein with persistence of incompetent lateral superficial femoral vein.

Fig. 90.—Uppermost tributaries of great saphenous vein emptying into lateral superficial femoral vein.

Fig. 91.—Uppermost tributaries of great saphenous vein emptying directly into femoral vein.

Fig. 92.—[illegible] excision of se[illegible] dale, W. W.: [illegible]

ligate them. This prevents the ligature from slipping off when the patient is walking. Alarming and embarras[illegible] was [illegible] hem[illegible]

Pheeters[35] reports two fatalities due to damage to the femoral artery during attempted saphenous vein ligation. There is considerable variation in the anatomical relationships of the great saphenous vein at the fossa ovalis. The pitfalls in ligation of the saphenous vein are described in detail by Stalker and Heyerdale[37] (Figs. 87–92). Daseler et al.[38] made a study of 550 anatomic dissections of the tributaries of the saphenous vein. They say: "In a study of the subcutaneous veins tributary to the great saphenous vein at or near the latter's termination in the fossa ovalis, it was found that vascular patterns (from 350 thighs) could be arranged in eight general types, according to the degree of complexity and of tributary fusion. Fusion of two adjacent tributaries entering one side of the saphenous vein occurs very frequently; fusion to produce a common trunk on each of the two sides in the same specimen is uncommon, as is also independent termination of all tributaries. However, no matter whether conjunction or separateness obtains, the tributaries enter the saphenous vein over the area of, or just distal to the lower margin of the fossa ovalis; in more than half of the cases they enter the saphenous in its upper 2 centimeters, and rarely over an area greater than 3.5 centimeters in length (measured downward from the femoral termination of the saphenous). These observations mean, surgically, that the area of required exposure of the saphenous vein need not be extensive; a length of approximately 4 centimeters would be more than adequate in most instances. Width of the area would be governed by the type of tributary pattern revealed in tracing the veins peripheralward from their terminations."

Many workers inject the distal segment of the ligated great saphenous vein with a sclerosing solution at the time of ligation. Zimmerman and his associates[39] believe that if injection of the distal portion of the divided vein trunk is not done at the time of ligation, "subsequent obliteration of the trunk of the vein may be impossible because of its deep position and the collapsed state of the vessel after it has been ligated." Retrograde injection at the time of high saphenous vein ligation is recommended by Pratt,[40] McPheeters,[41] Larson and Smith,[42] Sherman[43] and de Takáts.[44] The author feels that the safest procedure is to *omit the retrograde injection of the distal segment* at the time of the ligation. This view is urged also by Atlas[45] and Harkins and Schug.[46] Atlas[45] says: "The retrograde injection of a sclerosing solution into the distal portion of the divided saphenous vein at the time of operation is a widely accepted procedure. I am acquainted with 5 instances in which this maneuver was followed by a thrombosis of the deep veins of the thigh. Two of these patients died from pulmonary embolism, 1 suffered a pulmonary embolus but recovered, each of the other 2 developed a "milk leg" with permanent disability. As will be demonstrated later, anything injected into the saphenous system of a leg rapidly enters the deep venous system of that extremity. Ordinarily, thrombosis of the deep venous tree does not follow injections of sclerosing solutions into superficial varicosities because the patient is ambulatory, the deep venous tree is widely dilated, and the current of blood is swift, and hence the solution is rapidly diluted and does not have the opportunity to irritate the intima sufficiently to produce thrombosis. As will be demonstrated, there are even exceptions to this rule. However, when an individual is necessarily recumbent for a few hours during and after an operative procedure, the deep venous tree is not widely dilated nor the current of blood as swift. Consequently, any sclerosing solution finding its way into the deep veins has a better opportunity of irritating the intima sufficiently to produce subsequent thrombosis.

"To prevent this leakage of sclerosing solution through the communicating veins in the thigh into the deep venous tree it has been suggested that the *injection be made through* a ureteral catheter which has been passed down the length of the divided saphenous vein. As will be demonstrated, deposition

of sclerosing solution distal to the knee does not safeguard against leakage of the solution into the deep veins of the leg with subsequent thrombosis and pulmonary embolism. Besides, the passage of the catheter may injure the vein wall, the fluid leaks into the perivenous tissue, and a massive slough ensues." Tunick et al.[47] say: "The widely practiced procedure of saphenous ligation and retrograde injection of a sclerosing agent is commonly followed by a varying degree of arterial spasm in the homologous extremity. Such resultant arterial spasm may precipitate a further increase of arterial circulatory insufficiency in instances where an impaired arterial circulation already exists."

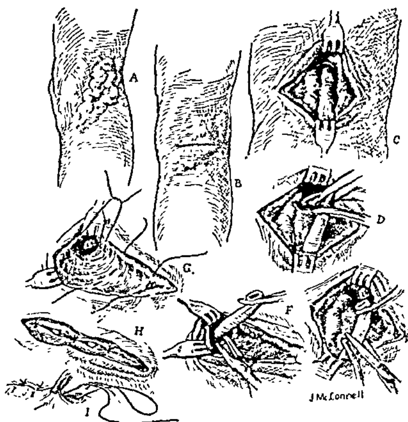
De Takáts[48] injects the distal segment with 50 per cent dextrose and 30 per cent sodium chloride, "varisol," keeping a tourniquet around the knee. When the saphenous vein fills rapidly in the Trendelenburg test, de Takáts ligates it just above the knee. Gault[49] advises "the formation of a thrombotic barrier by injection of 1 cc. of sclerosing solution into the internal saphenous vein at the level of the knee. The patient is asked to return in three or four days. If no thrombosis has occurred, the vein is reinjected with from 1.5 to 2 cc. of solution, according to the caliber of the vessel. Ligation and retrograde injection is performed when a firm thrombus has resulted. This usually takes from ten to fourteen days." The retrograde injection by ureteral catheter[50] is not advised. Atlas[45] gives the following valuable advice: "Prevention of leakage of sclerosing solution into the popliteal vein through the lesser saphenous vein is of paramount importance. Before a varix either in the thigh or leg is injected, a tourniquet is placed so that it fits into the crease behind the knee. At this point the lesser saphenous vein can be occluded just before it dips into the popliteal space to enter the popliteal vein. The tourniquet is left *in situ* for 5 minutes after the injection has been given. The patient stands during the entire procedure, and after the tourniquet is removed he is instructed to walk about so that any solution which might have entered the deep venous system can be rapidly carried away."

Ligation of the Lesser Saphenous Vein.—When the Trendelenburg test indicates incompetence of the lesser or short saphenous vein, its ligation in the upper part of the popliteal space is indicated. The details of this procedure are seen in figure 93.[51]

Ligation of Communicating Veins.—Incompetency of the intercommunicating veins is suggested by a "double-positive" Trendelenburg test. The operation to ligate these veins is difficult and for details the reader is referred to Linton's article.[52]

Technic of Injection.—A great many sclerosing solutions have been tried in the injection of varicose veins. The most commonly used agent is a 5 per cent solution of sodium morrhuate, usually combined with benzyl alcohol.[53] For the first injection 0.5 cc. is given. One cubic centimeter is the usual dose for a single injection, but as much as 2 cc. may be given. Two injections at different sites may be given at the same sitting. In quite a number of cases, an allergic response to sodium morrhuate has been reported. In addition to urticarial rashes at the site of the injection, severe and dangerous systemic reactions may occur. Lewis,[54] in making a report of a case, says: "It would thus seem as though sodium morrhuate solutions should be used with the greatest care in patients who have previously received the same solution, if a sufficient time has elapsed to allow the development of a foreign protein

sensitiveness. One should be doubly careful with individuals who are subject to asthma, hay fever or any other allergic phenomena." Dobson,[55] in reporting 2 cases of severe anaphylactoid reactions following the injection of 5 per cent sodium morrhuate in more than 4,000 injections, says that the patient should be carefully questioned in regard to reactions before each injection and that "small doses of not more than 0.5 cc. should be used for several injections on beginning the second and subsequent courses of injections when using sodium morrhuate." A preliminary test dose of 0.5 to 1.0 cc. of 5 per cent solution of sodium morrhuate or 5 per cent solution of monoethanolamine is given twenty-four hours prior to actual therapy by Weismann and Heyerdale.[56] McPheeters has never seen any serious reaction other than



[illegible]

urticaria and makes no effort to test his patients for an allergic response, whether they have been treated before or not.

Two per cent solution of sodium ricinoleate ("soricin") is very effective and is preferred by many to sodium morrhuate. The usual dose is 1 to 2 cc., but Sedwitz and Steinberg[57] have used a single massive injection of from 6 to 30 cc. "Monolate" (monoethanolamine oleate 5 per cent with benzyl alcohol) is similar [illegible] [58]
Shelley,[59] [illegible]
of monol[illegible]
2 per cent alkaloid quinine and 2 per cent benzyl alcohol) in 1500 cases and has found it superior to other agents. Schmier[61] believes 15 to 30 per

cent sodium chloride to be the best choice. Ethylamine* is recommended by Bowman.[62]

Mahorner and Ochsner[63] studied the effects of intravenous injections of sclerosing solutions on the subcutaneous tissues. They conclude:

"Subcutaneous injection of commonly used sclerosing solutions produces necrosis and an inflammatory reaction, a sterile abscess with subsequent repair by fibrosis. Rarely does it lead to ulceration of the skin. Five and 3 per cent sodium gynocardate, 5 per cent sodium morrhuate (Searle) and 40 per cent sodium salicylate produce more pronounced injury to cells locally than quinine and ethyl carbamate and 5 per cent sodium hydnocarpate, and the latter two in turn produce more severe injury than 70 per cent invert sugar and equal parts of 50 per cent dextrose and 30 per cent sodium chloride. This relation is similar to their relative effectiveness as thrombus producers as formerly shown by us experimentally by intravenous injection."

The technic of injection employed by de Takáts[64] is as follows: "The patient's leg should be in the *horizontal position.* This position, as particularly

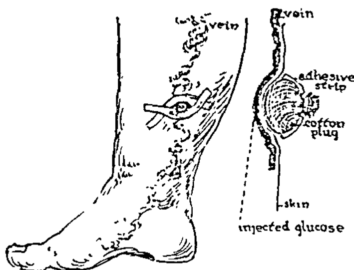


Fig. 94.—The vein is compressed after the injection with a gauze or cotton plug. This compression should be maintained for at least forty-eight hours. (de Takáts, G.: J. A. M. A. 92: 775, 1929.) McPheeters[66] feels that better obliteration is obtained if the vein is not collapsed after the injection.

emphasized by Sicard, is the one in which the blood is the most stationary and in which the relaxation of the calf muscles permits the injected fluid to stay in place for a longer period. As shown in a previous communication, the venous pressure with the leg in the standing position is so high in the varicose vein that the injected fluid is rapidly washed away to the periphery. Furthermore, this position of the leg is preferable for it permits as little blood as possible in the vein, thereby preventing unnecessary dilution of the hypertonic solution and insuring better contact of the irritant fluid with the intima. Usually two injections are made at one sitting, one at the highest palpable vein and the other at the lowest palpable dilatation of the same segment. We have never injected higher than the middle of the thigh, but we usually do not inject above the knee. After the selected site of injection is gently rubbed with alcohol, an intravenous needle, with short bevel, preferably of rustless steel and on a 10 cc. Luer-Lok syringe is inserted into the vein.

* "Ethylamine" "Etalate," Parke, Davis & Co.)

"As soon as blood can be aspirated into the syringe, the second and third fingers of the left hand gently strip the vein proximally and distally from the inserted needle, and maintain compression on the segment to be injected. Thus the vein is emptied as much as possible, before the injection is made. The injection is made slowly and is perfectly painless, as long as the needle is free in the lumen. When the needle is withdrawn, a dental pad, or a small felt pad, is placed on the site of injection and is pressed against the vein with a wide adhesive tape (Fig. 94). The pressure should be considerable, and its proper maintenance for at least forty-eight hours is very important. This pressure serves to keep the inflamed walls of the vein in the closest possible contact and thus favors obliteration" (de Takáts).

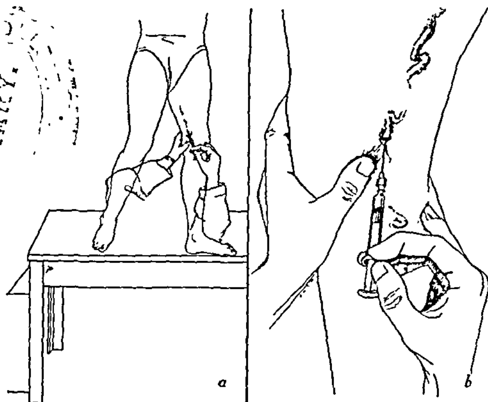


Fig. 95.—*a*, Relationship of patient to physician during therapeutic procedure; *b*, manual technic employed for injection therapy. (Weismann, R. E., and Heyerdale, W. W.: Am. J. Surg. 50: 738, 1940.)

De Takáts[65] has recently advised injection of the varicose vein as follows: (*a*) With the patient standing, the vein is marked; (*b*) the patient lies down and a blood pressure apparatus or tourniquet is applied above the knee; (*c*) the needle is placed in the vein, and (*d*) the tourniquet or blood pressure apparatus is loosened and the injection is made.

Weismann and Heyerdale[56] recommend that "the patient stand on a table or platform of a height at which the operator can work most comfortably from a sitting position (Fig. 95)."

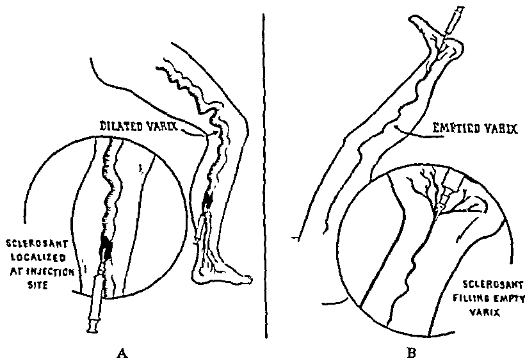
Atlas[45] injects the vein with the patient standing. He applies a tourniquet to fit in the crease behind the knee. "*At this point the lesser saphenous vein can be occluded just before it dips into the popliteal space to enter the popliteal vein.* The tourniquet is left in situ for five minutes after the injection is given. The patient stands during the entire procedure,

and after the tourniquet is removed he is instructed to walk about so that any solution which might have entered the deep venous system can be *rapidly carried away*."

Bellis and Churney[67] advise placing the needle in the vein, elevation of the extremity by an assistant to at least an angle of 45 degrees, waiting for the blood to drain from the vein and then injecting (Fig. 96). They add: "A small dry dressing is placed over the puncture site and an elastic bandage wrapped *from the ankle to the middle of the thigh. The extremity is then placed on several pillows and the patient allowed to remain in that position for twenty minutes,* following which the patient is allowed to be ambulatory. . . . Usually it has been possible to produce thrombosis of the entire varicose system by a single injection of sclerosant."

Brunstein[68] advises the following procedures to prevent extravasation and sloughing:

"Insertion of the needle at about one-third of an inch from the vessel to avoid puncture of the skin over the varix. This is imperative when injecting superficial, intracutaneous, bluish varices covered by only a thin layer of atrophic skin. It is obvious that necrosis and



[illegible]

sloughing will result from contact of an irritant solution with the weakened tissues surrounding the puncture. Injection into collapsed veins (empty vein technic) necessitates the introduction of the needle at a distance from the varicosity. Avoidance of dislodging the needle while pressure is exerted on the plunger. This is best effected by firm but gentle pressure of the fingers supporting the syringe on the extremity. This precaution will anchor the [illegible]

warning signal to discontinue the injection. The use of needles of small gauge (No. 25 or 26, ¾ to ⅞ inch long) will facilitate firm anchorage in the vessel lumen and prevent leakage of sclerosing solution into the surrounding tissues." He also advises adequate compression over a broad surface to maintain the collapsed state of the vessels, prevent swelling, avoid extension of massive thrombosis and obviate the spread of phlebitis.

McPheeters believes a better obliteration is obtained without collapse. These patients are ambulatory. De Takáts feels that walking after ligation

is a safeguard against the formation of thrombosis and the occurrence of emboli. The wearing of an elastic bandage or stocking is advisable during the whole course of treatment. There is no restriction as regards work.

Biegeleisen[69] reports successful results with a micromethod of intravascular injection of dilated capillaries (telangiectasia).

McAusland[70] emphasizes the importance of after-care following the injection of varicose veins. Constant standing and tight garters should be avoided. A supporting bandage or elastic stocking should be worn for a few weeks.

The complications after injection of varicose veins have been discussed by Cattell[71] and include the burning pain of the local reaction; the general reaction, which may be characterized by thirst, sweating, faintness, etc.; the latent general reaction which is characterized by nausea lasting twenty-four to thirty-six hours and is probably due to the use of too large quantities of the solution, and the latent local reactions. The last-mentioned complication may manifest itself as a marked local reaction at the site of an injection which has been correctly given, as an ascending periveniltis which may be alarming and predicates a long interval before the resumption of injections, and finally as sloughs and ulcers by the injection outside of the vein. Cattell believes that the ulcer can be prevented by the injection of normal saline solution or distilled water.

Kilbourne[72] says that sloughing or gangrene at the site of the injection is due to one of three causes, namely:

"1. The needle, at the moment of injection, is out of the vein. Sometimes this is because the needle has transfixed the vein.

"2. The needle has been correctly placed in the vein, but the solution has leaked out through the hole or holes made in the vein.

"3. A very thin-walled vein, receiving highly irritant solutions, may burst." The wide open area of gangrene may require months or years to heal. Rest in bed and proper fomentations are useful.

De Takáts[73] classifies the causes of failure in the treatment of varicose veins into seven groups: (1) mistakes in the diagnosis, (2) mistakes in the establishment of the indications, (3) mistakes in the type of treatment, (4) mistakes in the technic of injections, (5) mistakes in the selection of the solution to be injected, (6) mistakes in the measures taken to prevent or treat untoward reactions, and (7) mistakes in the after-treatment and follow-up of the patients.[74]

The subject of "*resting infection" in varicose veins* is discussed by de Takáts[75] as follows:

"1. Varicose veins are frequently infected. The source of infection lies in teeth, tonsils, and pelvic infections, acute respiratory infections or in varicose ulcers. Phlebitis in a varicose vein is a definite contraindication to injection treatment.

"2. In a group of cases, the infection subsided to a point where there are no clinical signs of inflammation. Nevertheless the trauma of injection treatment may activate the resting infection in the veins. Resting infection in other tissues, particularly in bones and joints, has received attention in the literature. It is characterized by the presence of pathogenic bacteria in the tissues which do not show any clinical evidence of activity. Such bacteria have been cultivated from varicose veins and are now being studied by Kendall.

"3. The acute thrombophlebitis as a result of a resting infection activated by the injection treatment is a typical picture. These patients should have proper support and may get up as soon as the rise in temperature subsides. They do not need prolonged immobilization like a deep phlebitis. The author believes that they are safer if treated ambulatory.

"4. The recognition of resting infection would eliminate a number of untoward inflamma-

tory reactions following injection treatment. The presence of a varicose ulcer does not seem to bring about such reactions during treatment, as if a local immunity had developed. The history of a previous phlebitis should force one to look for local symptoms. Tender, thickened veins, palpable phleboliths, but particularly a rise in surface temperature would suggest resting infection.

"5. To activate such resting infection, provocative measures, such as vein puncture, diathermy, roentgen ray may be employed. The obtained reaction is measured in 4 hours by the rise in skin temperature, preferably with a skin thermometer.

"6. When resting infection is diagnosed, injections should not be undertaken at that *time. Obvious foci of infection should be eliminated. Repeated small doses of roentgen* ray, mild protein therapy, together with adequate support of the limb may clear up the residual infection. Three months later the provocative tests may become negative, at which time the injection treatment is permissible. The infection, however, may not clear up for years, particularly if the site of infection is in the pelvis."

Sedwitz[76] suggests the intravenous injection of 10,000 units of heparin every four hours on the day after injection of varicose veins in "individuals presenting: (1) swelling of the leg sufficient to increase the circumference one and one-half inches at the ankle, one inch at the calf and two inches at midthigh; (2) tenderness and discoloration over and about the veins; (3) sharp cramplike pains traversing the veins to the inguinal and lower abdominal regions; (4) evidence of impaired circulatory function of the leg, using oscillometer, estimation of circulation time and venous pressure, sedimentation time and white blood cell count." The clotting time is taken before each injection, and when it reaches ten to twelve minutes, the injections are stopped.

The Operative Treatment of Varicose Veins.—De Takáts operates radically in about 4 per cent of his cases. He says,[77] "The reflux from the deep veins can be logically attacked only by interrupting the communications between the deep and superficial venous system. f radical surgery is resorted to, it should really be radical. The ligation of the saphenous vein should be done as high as possible, with an incision about two fingerbreadths below [illegible] ...e as [illegible] the [illegible] nore important than the removal of an isolated dilated segment. The operation is preferably done under spinal anesthesia, the patient is not immobilized longer than four to five days after operation."

Some surgeons keep their patients in bed two or three weeks.

The operative treatment of varicose veins includes ligation and excision of the long trunks. These operations may very satisfactorily be carried out under local anesthesia. The great saphenous vein is ligated at its highest palpable point. The excision of large venous trunks is generally brought about through longitudinal incisions directly over these trunks. The veins are marked on the skin with silver nitrate or indelible pencil before operation. The employment of multiple incisions, each 3 to 5 inches in length, is probably more suitable than the use of extremely long incisions. The Mayo dissector is a long instrument with a small rounded eyelet at right angle to the end. Through a small incision the vein is doubly ligated and cut between the ligatures. One end of the vein is then threaded through the eyelet of the Mayo dissector. This is then forced subcutaneously along the path of the vein for a distance of 3 or 4 inches from the first incision. The second incision is then made [illegible] of making a [illegible] branches of [illegible] tip, is inserted in the vein to a considerable distance; the vein is tied and removed by inversion. Hodge et al.[78] combine vein stripping with high ligation and pressure bandages.

The ingenious [illegible]

A compression bandage is applied. Smith[80] uses diathermy in the treatment of varicose veins.

Varicose Ulcers.—A most distressing complication of varicose veins is the occurrence of *varicose ulcer* (*ulcus cruris*). No outpatient department or dispensary is free from a dismal parade of these victims of chronic leg ulcer

(Fig. 97). The ulcer may be very severe and disabling. The basic cause of varicose ulcer is the stagnation of fluid in the tissues which results from varicose veins. The local resistance of the tissues to infection or trauma becomes

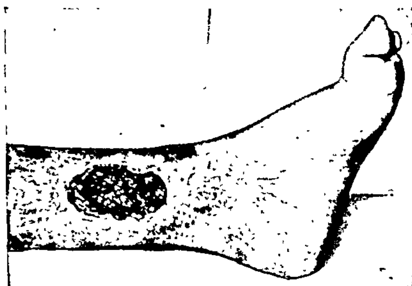
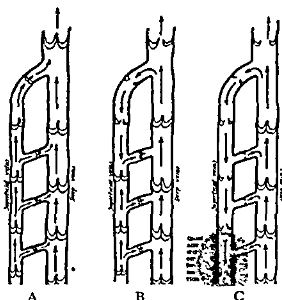


Fig. 97.—Varicose ulcer.

diminished. McPheeters'[81] diagram (Fig. 98) indicates the mechanics of the stasis. The immediate cause of the ulcer may be a small trauma or an embolus from an infected tooth or tonsil.



A B C

Fig. 98.—*A*, Nominal flow in superficial and deep veins. *B*, Beginning reflex in superficial veins. *C*, Complete loss of valve function in superficial and communicating veins. (McPheeters, H. O : Surg., Gynec. & Obst. 47: 469, 1928.)

The differential diagnosis of varicose ulcer modified from McPheeters is as follows:

[illegible] the most common ulcerating condition of the lower extremi- [illegible] there is usually [illegible] or several inches beyond the open ulcer. The ulcer as well as the surrounding tissues may be very tender.

The edges are usually sloping, and the base is ordinarily covered with large, coarse granulations and a grayish exudate. The discharge may be very profuse. As already stated, the dilated varicose veins with their influx and accompanying congestion are accepted as being the cause of the varicose ulcer. One can nearly always find these large venous channels about the ulcerating area. Sometimes the veins lead directly into and under the ulcer, and in these cases a positive diagnosis can be made.

2. The syphilitic ulcer usually has punched-out, sharply defined edges, which at times are raised. It is ordinarily deeper than ulcers arising from other causes. The base is dark red and has large granulations, which may be unusually large in the larger ulcers and may bleed very readily. Much serum exudes from the surface, but this does not give the impression of being pus. Luetic ulcers may assume any shape or condition. In addition to the clinical appearance, a positive Wassermann reaction and often a history of the original infection are obtained.[82]

3. The tuberculous ulcer is uncommon on the lower extremities. The edges are usually undermined. Some authors state that it has a tendency to progress, with an irregular border outline giving the impression at times of a half circle, but this is not a tuberculous characteristic. The base is seldom red and granulating, as in the luetic ulcer, but more frequently is covered with a grayish necrotic exudate. It is thought that the tuberculous ulcer is always secondary to tuberculosis elsewhere. Knowledge of active tuberculosis elsewhere would, of course, be a definite diagnostic aid.

[illegible]

which is seen with varicose ulcers. There would be no varicose veins except as a coincidence, and there would be no response to the usual treatment. With a negative Wassermann reaction, with no symptoms or signs of tuberculosis and with no response to the usual ulcer treatment, a biopsy should be made to confirm the diagnosis.

5. Trophic ulcers can usually be diagnosed without difficulty after consideration of the clinical history. These lesions are characterized by their tendency to slow healing.

6. The mycotic ulcer, according to Ochsner,[83] occurs more frequently than is generally supposed. [illegible]

"Blastomycosis is the most frequently encountered mycotic ulcer of the extremities. The original lesion or papule usually follows a trivial injury. The papule extends peripherally and ulceration occurs. Characteristically there is a tendency for central healing with peripheral extension. The edges of the ulcer are raised and sharply defined. Surrounding the ulcer are multiple abscesses which contain mucopurulent material. These in turn may rupture, producing numerous peripherally located ulcers. The ulcers are painless. The edges of the ulcer are separated from the normal skin by a distinct hyperemic zone.

"Actinomycosis: The ray fungus, or actinomycete, is frequently the cause of chronic ulceration of the lower extremities. Actinomycosis is characterized by multiple cutaneous and subcutaneous chronic abscesses, which may rupture spontaneously or be incised. The wall of the abscess and subsequently the wall of the ulcer is composed of granulation tissue beyond which is a layer of dense fibrous tissue. Characteristically in actinomycosis there are multiple sinuses in the ulcers, from which a thick yellow pus exudes, in which the sulphur granules may be demonstrated.

"Sporotrichosis occurs relatively infrequently in the lower extremities, being found much more frequently in the upper extremities. It is characterized in the beginning by red, painless nodules associated with ascending lymphangitis and localized lymphadenitis. Multiple ulcers occur along the course of the lymphatic chain. These ulcers are characterized by overhanging edges and exuberant granulation tissue. The discharge consists of thick, yellow pus.

"All mycotic ulcers have a rather characteristic musty odor which has been compared by Bevan to that of freshly turned sod. The diagnosis is made by finding the specific fungus, which may be in [illegible]

[illegible] to 1000 or 1500 grains daily, should be administered. It will be well to begin with doses of from 25 to 30 grains, three times a day, and increase 15 grains daily. x-Ray or radium radiation in massive doses constitutes the best method of treatment." (See also chapter II.)

7. **Ulcers in Sickle Cell Anemia.**—Numerous authors have reported the presence of ulceration of the lower extremity in sickle cell anemia. It is a simple inflammatory ulcer whose base is composed of granulation tissue without a covering necrotic membrane. With rest in bed and the application of a mild ointment, the prognosis is good.

8. **Leg Ulcers Due to Thyroid Dysfunction.**—Cohen[84] reports a case of deep ulcerations of the lower extremities in a patient with myxedema. The ulcers healed rapidly with the administration of thyroid extract.[85]

9. **Diabetic Ulcers.** (See Diabetic Gangrene.)

The Local Treatment of Varicose Ulcers.[86]—In the measures to be described in the following paragraphs for the treatment of varicose ulcer, it must be constantly borne in mind that *the most important part of the treatment of varicose ulcer is the preliminary or coincident treatment of the varicose veins.*

I agree with Cattell[87] "that once the patient has had an ulcer there is always a tendency to reformation of the ulcer, following an injury or following a possible recurrence or reformation of the veins."

Practically all varicose ulcers may be healed by the simple but generally impracticable expedient of putting the patient to bed with the leg elevated and using continuous, warm boric fomentations. After the infection has been eradicated and the ulcer has a clean granulating base, the healing may be expedited by skin grafting. If no treatment, however, has been directed toward the varicose veins, the ulcer is liable to recur promptly when the patient is ambulatory again.

Lovell[88] has obtained excellent results in palliative treatment of chronic stasis ulcers of the lower extremities by the topical use of penicillin (500 units of sodium penicillin per cubic centimeter of normal saline solution). Kozoll et al.[89] have had good results with wet dressings of tyrothricin. Boehme[90] praises an ointment containing 1 per cent water-soluble chlorophyll. Red blood cell paste has been found useful in the treatment of ulcers.

For patients who are necessarily ambulatory, a reliable treatment is the application of an *Unna paste boot.* The composition of Unna's paste is:

Zinc oxide	1000 Gm.
Gelatin	600 Gm.
Glycerin	1400 cc.
Distilled water	2200 cc.

De Takáts[92] believes that the following formula gives the most satisfaction:

Zinc oxide	100 Gm.
Gelatin	200 Gm.
Water	300 cc.
Glycerin	400 cc.

This material is cut up in slices and warmed on a water bath before being used.*

The technic of applying the Unna paste boot is as follows: The leg is thoroughly cleansed with soap and water, especially the ulcer itself, and is

* [illegible] commercial prep- [illegible] ncil on Physical [illegible]

thoroughly dried. Devane[93] applies a rubber sponge to the ulcer so that it extends ½ inch all around the edges. The Unna paste, which has been melted in a water bath (Fig. 99) and cooled to a temperature which will be tolerated by the skin, is then painted on the leg with a large brush, from just below the knee to the ankle (Fig. 100, *A*). While it is still moist, the leg is enveloped in a very smoothly and carefully applied single layer of gauze bandage, care being taken not to reverse the bandage, because of danger from wrinkles (Fig. 100, *B*). A second coat of the melted Unna paste is then applied and over this a second layer of gauze bandage (Fig. 100, *C*). Frequently these two layers will suffice, but if more support is required a third layer may be applied. Cannon and Lowenfish[94] apply the bandages already soaked in the warm solution of Unna's gelatin glue. These writers do not advise cutting a window in the cast for access to the dressing, because it removes the uni-

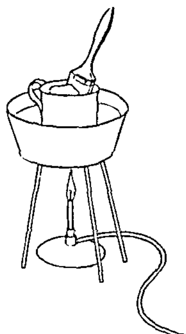


Fig. 99.—Unna paste being melted in a water bath. (de Takáts, G.: Bulletin of the Varicose Vein Exhibit, American Medical Association Meeting, June, 1931.)

form support of the parts. Lowenfeld[95] says that when other methods of healing the ulcer have failed, the epithelial implantations of Braun are of value. A superficial cutaneous area is taken from a sound place on the patient's thigh or from another person and cut up into very small particles while in physiologic salt solution. Oblique deep canals are bored with a sound into several places of the ulcerous surface, and one of the cutaneous particles is cut into each of them, so that it disappears entirely below the surface of the ulcer. According to Braun, rapid growth of epithelium ensues from these epithelial implantations over the ulcer surface and leads to the local epithelization of the granulation surface and, by confluence of the newly formed cutaneous islands, to the cicatrization of wounds in large defects which otherwise would heal badly. Credé ointment (metallic silver) has been useful, and Pfab[96] has praised silver chloride salve.

In 85 per cent of 300 cases of chronic leg ulcer, Sooy[97] has secured complete

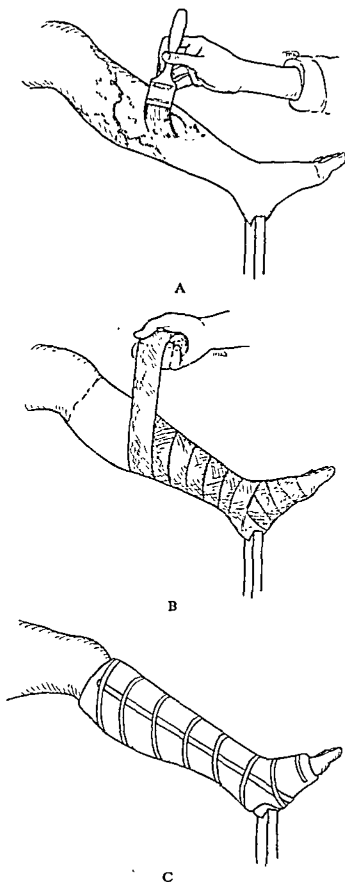


Fig. 100.—*A*, Application of Unna's paste to varicose ulcer and veins. *B*, Application of bandage over Unna's paste. *C*, Completed Unna's paste cast. (de Takáts, G.: Bulletin of the Varicose Vein Exhibit, American Medical Association Meeting, June, 1931.)

healing with a modified form of Unna's paste, the formula of which is as follows:

Glycerin...	1900 Gm., 1425 cc.
Gelatin............... ..	625 Gm.
Water..................	1900 cc.
Zinc oxide...............	250 Gm.
Phenol...	1.50 per cent of total volume
	4675 Gm., 10 pounds (sufficient for 7 dressings)

Cutting[98] advises elevating the leg for five minutes before the application of Unna's paste boot and cautions against making reverse turns or folds in the bandage.

The "sponge-heart" technic for treating varicose ulcers which is recommended by McPheeters and Merkert[99] is as follows:

"1. Cleanse the skin and ulcer area with gauze wet with benzine.

"2. Apply 10 per cent silver nitrate to the ulcer. This stimulates but is of no value at the first dressing of a badly infected and necrotic ulcer.

"3. Apply some mild ointment to the ulcer area that will remain *soft*. Many ointments dry and cake.

"4. Apply several layers of fluffed gauze.

"5. Cover this with 4 layers of sheet wadding or cellucotton.

"6. Select a *good grade* rubber bath sponge (firmest possible), that is 1 inch larger than the ulcerating area.

"7. Bandage this all in place with a 3-inch plain gauze bandage. Be very careful that the dressing and sponge do not slip to one side.

"8. Apply a 4-inch Ace bandage from just below the knee to the toes over the sponge and dressing. Bandage firmly. The more cellulitis and the worse the ulceration the tighter the bandage must be applied. Apply it as a double figure of eight about the foot and ankle (Fig. 101).

"9. Sell the patient *completely* as to the point that *the more he walks* with the leg thus bandaged, the *quicker* will the ulcer heal.

"10. *Never* apply the sponge and bandage described to a bed patient.

"11. Change the dressings often enough to keep them from becoming saturated. Every two days is preferred. The rubber sponge can be boiled up and used again when soiled, but should be discarded as soon as it has lost its kick and has become firmly pressed together.

"Observation of an ulcer after a few days' use of the sponge and Ace bandage associated with walking will often amaze one with the rapidity with which the old, sloughing or hydropic tissues can be converted into clean, fresh granulations which bleed easily with a bright, fresh arterial type of blood. The secretion from the ulcer surface diminishes rapidly, the cyanosis of the ulcer disappears, the edema of the surrounding tissues melts away, the tissues become soft and tend to approach the normal. Thus, ideal conditions are maintained for the ulcer healing, the end-results are reached in a comparatively short period, and the patient continues on at work during the entire time. Such cannot be said of any other method of treating varicose ulcers today."

In large ulcers, Wright[100] buries small skin grafts ur[illegible] ulcers with adhesive plaster. Firm bandaging of the [illegible] adhesive bandage* has been emphatically praised b[illegible]

* Elastoplast, Duke Laboratories, New York. Also, Ace Adhesive Bandage, Becton, Dickinson & Co.

directly over the ulcer. This method has been endorsed by Shands.[102] Douglas[103] reported prompt healing under adhesive plaster in 96.7 per cent of chronic ulcers, most of which had been refractory to other nonoperative forms of treatment. An excellent proprietary ointment for the ambulatory supportive treatment of varicose ulcers is "calzo."* (See section on Wound Healing.)

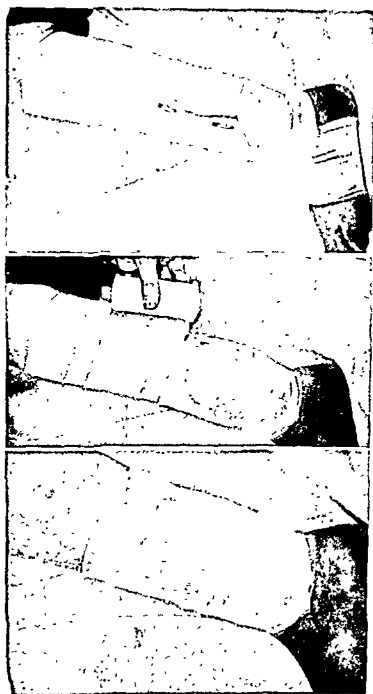


Fig 101.—Dressings for varicose ulcer. *a*, Sponge and dressings bandaged in place with 4-inch plain gauze bandage. *b*, Ace bandage (4-inch) being applied from above downward. *c*, Lower leg completely bandaged with Ace bandage (4-inch) from knee to toes, double figure of eight wrapping about the ankle and foot. This holds the rubber sponge or "venous heart" in position over the ulcer, which gives the "pumping effect" on walking. (McPheeters, H. O., and Merkert, C. E.: Surg., Gynec. & Obst. 52: 1164, 1931.)

Krinsky[104] advocates the use on alternate days of 5 per cent gentian violet solution in the treatment of varicose ulcers. Thurman and Chamison[105] use 2 per cent aqueous solution of gentian violet applied three to five times a day for two or three days until a firm, adherent crust is formed. No bandages are used If edema is present, treatment should be given to control it before gentian violet is used

* Physicians & Hospitals Supply Company, Inc, Minneapolis.

McPheeters[106] says: "The fungus infection associated with the secondary extensive weeping eczema and dermatitis so often seen with ringworm infection of the feet is markedly aggravated by the presence of large varicose veins. The latter should be treated just the same as in any other case. Rusten believes that most of the skin reaction is allergic in nature and secondary to products formed and liberated in the original infected area. The best results are obtained when the patient is put to bed with the lower leg in high elevation and in packs saturated with Burow's solution diluted 1 to 10 with cool water. Small amounts should be applied every half hour so as to keep the few layers of gauze continually wet. The application of a 5 per cent alcoholic solution of gentian violet or any good antiseptic over the area of the active course of the fungus is correct and should be done twice a day. After the weeping has stopped, applications of zinc oxide and olive oil are commonly used over the recently inflamed areas. All of the patients recover more quickly if the period of bed rest is lengthened at first. Following this the patient must have support for a long time." Saylor, Kovacs, Duryee and Wright[107] reported excellent results of treatment of varicose ulcers of ambulatory patients who received no injection while under treatment by means of acetyl-beta-methyl-choline chloride (Mecholyl, Merck & Co.) by *iontophoresis*. Their technic is as follows:

"A standard 0.5 per cent solution of acetyl-beta-methyl-choline chloride is used. Reinforced asbestos paper is saturated with the 0.5 per cent solution of the drug and wrapped around the foot and leg as high as the knee. The ulcerated area is not covered during treatment until a firm scab has formed over it. After this has occurred, the application may be made directly over the healed area also. A malleable metal plate is placed over the wet asbestos paper and connected to the positive pole of a galvanic machine. The metal plates are never applied over the ulcerated area. A large, regular moist-pad electrode is used as a dispersive electrode. This is placed under the back and connected with the negative pole. The current is turned on and slowly increased to 20–30 milliamperes. At the end of the treatment, the current is slowly reduced and turned off. Treatment is given in some cases daily, but generally two to three times weekly for from twenty to thirty minutes." Trout[108] excises the diseased tissue and underlying fascia in cases of intractable ulcer and has found it successful in 41 cases treated. After preparation of the ulcer by rest in bed and compresses of boric or chlorinated soda solution Linton[109] carries out cutaneous grafting.

In ulcers which do not produce any satisfactory granulations but have a dirty grey or yellow glistening base, Albee[110] has had success by drilling the bone cortex beneath the ulcer. This allows blood to well up, and healthy granulations follow A 90 per cent paraffin and 10 per cent vaselin dressing is applied to the leg put in a plaster cast for a week. In over two thirds of Albee's 19 cases the ulcer healed.

PERIPHERAL VASCULAR DISEASE

Reid's[111] classification of peripheral vascular disease is as follows:

A. Primary vasomotor disturbances
  (a) Vasoconstrictor disturbances
    1. Raynaud's disease
    2. Acrocyanosis (acro-asphyxia chronica; acroparesthesia; sclerodactylia)
  (b) Vasodilatory disturbances
    1. Erythromelalgia
    2. Acute painful osteoporosis (?)
B. Primary organic diseases of the arteries
  (a) Traumatic (chemical and thermal)
    1. Embolism and simple thrombosis
    2. Arteriovenous aneurysm
    3. Phenol and all caustics
    4. Frostbite
  (b) Inflammatory (toxic)
    1. Thrombo-angiitis obliterans
    2. Specific arteritis (syphilis, tuberculosis, periarteritis nodosa pyogenica)
    3. Nonspecific arteritis (exanthemata, typhus, typhoid, pneumonia)
    4. Nonspecific arteritis (chronic toxemia, ergotism)
    5. Endarteritis obliterans (cause undetermined)
  (c) Degenerative changes
    1. Arteriosclerosis (senile, diabetic, and Moenckeberg)

The differentiation between organic and spastic occlusion is of importance from the standpoint of treatment. In the former the aim of therapy consists of: (1) increasing the collateral circulation; (2) relieving pain and (3) removing dead parts of the limb by amputation. In the latter, one should try to relieve the spasms by physical means, drugs or sympathectomy (de Takáts). De Takáts recommends use of the peripheral nerve block test and the dia-

DIFFERENTIAL DIAGNOSIS OF VASCULAR DISEASE AFFECTING THE EXTREMITIES

(Varicose Vein Committee, American Medical Association, 1930)

	Varicose veins.	Thrombo-angiitis obliterans.	Arteriosclerosis	Raynaud's disease.	Erythro-melalgia.
Age	From puberty on	Mostly between 25 and 40 years.	Mostly between 55 and 85 years	Mostly between 17 and 35 years.	Mostly between 35 and 50 years.
Sex	Females, 54 per cent	Males, 99 per cent	Males, 90 per cent.	Females, 95 per cent.	Females, 70 per cent
Race	Any	Jews, 50 per cent	Any.	Any.	Any.
Heredity	Dominant influence	?	Marked influence	Marked influence	Not known.
Pulsation of arteries	Normal	Pulseless, 50 per cent, diminished 45 per cent, normal 5 per cent	Pulseless, 50 per cent, diminished 45 per cent, normal 5 per cent	Normal	Normal
Dependent rubor	Absent	Present.	Present	Absent.	Absent
Pallor on elevation	Absent	Present	Present	Absent	Absent
Claudication	Absent	Usually present	Usually present	Absent	Absent.
Rest pain	Usually absent	Severe, sharp and stinging	Mild, aching	Usually absent.	Burning
Cramping and tingling on standing	Frequent	Mild	Mild	Usually absent	Absent.
Ulcers	Moist around ankles.	*Inflamed discharging on toes*	*Usually dry above bony prominences*	*Absent*	*Absent*
Phlebitis	Frequent	Thirty per cent of cases recurring	Absent	Small, punched out areas	None
Edema.	Frequent	Frequent	Infrequent.	Absent.	Absent
Roentgenogram of arteries.	Negative	Usually negative	Positive for sclerosis	Negative	Negative
Color changes following exposure to cold	Never	30 per cent	15–20 per cent	Always	Never
Skin temperature	Normal	Low	Low	Low	High
Histamine reaction	Normal.	Absent	Absent	Normal	Not tested

thermy test as valuable in making a differential diagnosis. In the peripheral nerve block test the posterior tibial nerve is blocked with novocain until complete anesthesia of the plantar surface of the foot is obtained. If complete vasodilatation with a rise in skin temperature accompanies the block, then the changes are due to vascular spasm. When no rise in temperature takes place after the nerve block, the occlusion is due to organic causes. A partial rise in temperature may mean that both causes are concerned in the occlusion

De Takáts[112] stresses several points in the examination of patients with peripheral vascular disease. The pulse of the dorsalis pedis, posterior tibial, popliteal and femoral arteries should be palpated. Absence of a palpable pulse generally, but not always, indicates an obstruction of the vessel. A lowered skin temperature indicates an inadequate arterial flow. "Pallor on elevation, which can be accentuated by rapid dorsal and plantar flexion, and rubor in the dependent position are signs of diminished blood flow." (de Takáts) The cutaneous histamine reaction is of value. "The acid phosphate salt of histamine in a 1:1000 solution is obtainable in ampules. When 0.1 cc. is injected intradermally within five minutes a characteristic flare is produced, with a wheal in the center. This flare is absent when (1) there is not enough head pressure in the skin vessels to fill up the arterioles dilated by histamine, (2) when an arterial spasm exists, which the histamine is unable to overcome, or (3) when the sensory nerves of the skin have degenerated, following peripheral nerve injury." (de Takáts) The difference in blood pressure of the two extremities will give important information.[113]

The Varicose Vein Committee of the American Medical Association at its 1930 exhibit presented a valuable table of differential diagnosis which was prepared from the combined statistics of Allen, Brown and Mahorner, of the Mayo Clinic, and of de Takáts and Quint. Their table is reproduced here in its entirety.

Thrombosis and Thrombophlebitis.* (*See also the discussion of postoperative thrombophlebitis under Postoperative Care.*)—Thrombosis has been described by Buerger as a plug formation in a vessel which may bring about practically complete closure of the vessel lumen. Thrombophlebitis occurs when infection has been superimposed upon thrombus formation.[114]

Barker[115] reviewed 1011 cases of thrombophlebitis at the Mayo Clinic and submitted the accompanying classification.

Tentative Classification of Types of Thrombophlebitis (Barker)

Local	Chemical Traumatic; early and delayed Varicose; spontaneous Infectious and suppurative
Hematogenic	Blood dyscrasias
Secondary (complicating)	Postoperative Postpartum With various infectious diseases, pneumonia, typhoid fever, influenza
Primary	Thrombo-angiitis obliterans Idiopathic

According to Homans,[116] the principal factors favoring venous thrombosis are: "First, inflammation of the vein wall, a factor of great potential importance, little understood as yet, and undoubtedly influenced by advancing years; second, changes in the blood itself, whether in the nature of depletion or related to the obscure influence of trauma; and third, the slowing of the venous return from the legs, dependent upon confinement to bed and aggravated by increased abdominal tensions. Such factors tend to cause thrombosis in certain especially susceptible vessels, notably the femoro-iliac veins and those of the calf and popliteal space."

The studies of Edwards and Edwards[117] show that complete thrombosis produces, "actually or functionally, a valveless vein." Hunter et al.[118]

* See also section on Postoperative Thrombosis and Embolism.

dissected the femoral and adductor veins in 200 autopsies. They say: "Like others who have examined the femoral vein, we find that phlebothrombosis of the lower extremities begins in the deep vessels of the calf and tends to propagate toward the heart, and that thrombosis of the femoral veins alone is an uncommon occurrence. Both sets of veins are the most frequent, and for this reason the most important, of all the possible sources of both fatal and nonfatal pulmonary emboli."

Homans[119] describes four of the commoner varieties of thrombophlebitis, as follows:

Phlegmasia Alba Dolens; Femoro-Iliac Thrombophlebitis; "Milk Leg."—This form commences in the upper femoral and the external iliac vein and leads to edema of the entire limb, although swelling may be absent. The other leg is often involved but often with little swelling.

"As to treatment, it is enough to say that elevation of the lower limbs above the level of the body for the purpose of drainage is essential, and that the affected leg should not be immobilized but exercised gently at the earliest possible moment. . . . Once edema has disappeared, the use of the limb, first in an elevated and then in a dependent position, may gradually be resumed. For some months a bandage or elastic stocking for the lower leg is often required."

Deep Peripheral Thrombophlebitis; Thrombophlebitis of the Calf Muscles.—This is a treacherous disease and as a rule is silent.

"The exciting cause is usually some minor injury or strain of the lower leg or foot. Following this, there is a little soreness of the calf muscle on use, especially on going upstairs. The ankle swells slightly. Merely going to bed often causes all signs of the disease promptly to disappear. There is no tenderness and only perhaps a little soreness on stretching the Achilles tendon (*Homans' sign*). As a rule, elevation causes the proximal end of the thrombotic process to heal, but occasionally on renewed use of the leg the whole picture reappears."

Homans feels that this form of thrombophlebitis is a relatively common source of pulmonary embolism. When elevation is not followed by relief, probably the femoral vein should be divided to forestall embolism. Excision of veins for suppurative thrombophlebitis has been reported by Bancroft[120] and Neuhof[121] Lindgren[122] says that a weakened femoral pulse is a frequent and early, if not constant, phenomenon in thrombosis of the deep veins. Treatment consists of elevation, which is obtained by raising the foot of the bed 15 cm. and placing the unbandaged leg on a soft pillow. After ten days the leg is exercised freely, the patient being in bed, and a semi-elastic bandage is used as an upright position is gradually resumed.

Superficial Thrombophlebitis in Non-Varicose Veins.—This condition includes phlebitis migrans and is perhaps familial. When it is obstinate it tends to spread. Thromboses below the knee disappear on elevation of the leg, but when they occur at or above the knee, high division of the great saphenous vein may be usefully combined with elevation.[123]

Thrombophlebitis in Varicose Veins.—Embolism is rare in this type of thrombosis, and the treatment virtually ignores its possibility. If the thrombosis is localized in the calf, an elastic adhesive bandage can be applied and the patient allowed to go about his business. "It is astonishing how rapidly under these conditions a cure occurs. If the process has reached the groin, elevation of the leg, as in other cases of thromboses, is effectual. On the other hand, if high division of the saphenous vein above the thrombosed area can

be accomplished, the immediate cure is more rapid, and a recurrence is forestalled."

Thrombophlebitis and Phlebothrombosis. Ochsner[124] classifies intravenous thromboses into two major types, namely, thrombophlebitis and phlebothrombosis. He says: "The clotting in thrombophlebitis is the result of injury to the vascular endothelium from mechanical trauma, chemical injury, or bacterial invasion, whereas in phlebothrombosis, the intravascular thrombus formation is due to alterations in the cellular and fluid constituents of blood, which increase the clotting tendency, and to venous stasis. The clinical manifestations of the two types of intravenous clotting are entirely different. In thrombophlebitis, the symptoms are marked, whereas in phlebothrombosis there are few, if any, clinical manifestations. The prognostic significance of this differentiation lies in the fact that in thrombophlebitis, unless there is suppuration, which is rare, the clot is firmly adhered to the vein wall and therefore is not likely to become detached and result in embolism. Because of the associated inflammatory process, it is usually accompanied by profound arterial spasm resulting in edema which may persist and cause prolonged disability. On the other hand, the coagulum in phlebothrombosis is loosely attached to the vein wall and can be detached easily, resulting in embolism. The therapy of the two conditions is also different. Because the clinical manifestations in thrombophlebitis are due to associated vasospasm, the relief of vasospasm usually results in prompt relief of symptoms and subsidence of the lesion. On the other hand, in phlebothrombosis, either thrombectomy or the ligation of the vein above the thrombus is imperative in order to prevent a possible fatality from pulmonary embolism."

In *thrombophlebitis* there is a varying degree of fever, and if there is suppuration, there may be chills and a septic type of temperature curve. Pain and swelling due to ischemia and to obstruction of the venous channel also are noted. The leukocyte count is usually elevated. Although the symptoms are marked, there is little danger of embolism. If the prophylactic treatment (See section on Postoperative Care) has been unsuccessful, Ochsner says: "in nonsuppurative thrombophlebitis, because the symptoms are the result of arteriolar spasm, the treatment consists of overcoming the vasoconstriction by anesthetization of the regional sympathetic ganglia." The pain is relieved, and the fever and edema rapidly disappear.

Homans[125] says: "The essential difference between phlegmasia alba dolens and an advanced, quiet thrombosis (phlebothrombosis) lies in the as yet unexplained inflammatory reaction about the great artery and vein in the femoral and iliac regions. For only when the venous stream is fully obstructed by a solid thrombus does this reaction set in, giving rise to the edematous limb, enlarged from toes to groin, often painful and usually marked by tenderness over the femoral vessels, together with some perivascular inflammatory thickening at the groin. The reaction may be minimal or may take the form of an acute, nonsuppurative exudate involving the nearby nervous and lymphatic structures quite as much about the artery as the vein. . . .

"The clinical evidence of a deep, quiet, venous thrombosis in the calf is obviously quite different in ambulatory persons and in those already confined to bed. No age beyond infancy is free from the accident of thrombosis, though it is most common in the 6th decade and beyond. When attacked in active life, the individual may notice some degree of lameness of the calf in

walking, some little edema of the ankle; occasionally, only such vague symptoms as hardly to trouble a busy person. There may have been a minor accident or unaccustomed strain. Any lameness and swelling which are present will be relieved by a few days' rest in bed but will recur on renewed use of the limb.

"When thrombosis occurs during posttraumatic, postoperative or postpartum life in bed, or in the course of any serious illness, there may be even less to call attention to the local disease. It is under these circumstances that embolism is so apt to come out of a clear sky. However, there is often pain in the calf, ranging from mere soreness to a real ache. There may or may not be some swelling of the ankle and lower leg. There may be tenderness of some of the toes, of the foot or of the calf. More especially, there may be *some sign of irritability* of the great posterior calf muscles. This can be brought out by strongly dorsiflexing the foot—dorsiflexion sign. The muscles may merely resist passive dorsiflexion, which will be less complete than upon the opposite side, or there may be discomfort, referred to the back of the calf or the popliteal space. The muscles, to the grasp of the fingers, will often feel full and a little tense. Finally, if the individual can sit or stand up, the foot of the dependent leg will perhaps appear faintly cyanotic, again as compared with the opposite side. It may be necessary to leave the legs dependent for several minutes to bring out this sign."

The technic of *lumbar sympathetic block* is given by Ochsner[126] as follows: "The patient is placed in the lateral recumbent position. This position is used rather than the prone position which is usually employed for the lumbar sympathetic block in peripheral arterial disease, because usually a patient with thrombophlebitis is too ill to be placed in the prone position. The thighs are flexed on the trunk in an attempt to straighten the lumbar curve. The sites of puncture in the skin are determined by taking points approximately two fingerbreadths lateral to, and on a horizontal level with, the spinous processes of the first, second, third, and fourth lumbar vertebrae on the affected side. The spinous processes are chosen because the transverse processes are on a level with them. A cutaneous wheal is made at each one of these points. Special (B.D.) 20 gauge short beveled needles, 14 cm. in length, are introduced at each point vertical with the skin surface until the transverse process is reached. The transverse process is used as a landmark, because, whereas there may be considerable difference in the thickness of the subcutaneous fat and the sacrospinal muscle in an obese, muscular man and a thin, emaciated woman, there is relatively little difference in the thickness of the bodies of their vertebra. After striking the transverse process, the direction of the needle is slightly changed, either above or below the transverse process, and the needle is inserted approximately two fingerbreadths beyond the process. The point of the needle then lies on the anterolateral surface of the body of the vertebra where the sympathetic chain lies. Through each needle, 5 to 10 cc. of 1 per cent procaine are injected after first aspirating to determine that the point of the needle is not within the vessel. The procaine anesthetization is repeated daily as long as the patient has fever, because it is our belief that the persistence of fever is an indication of the persistence of the inflammatory process and that as long as the inflammatory process exists in the vein there is a likelihood of vasospastic impulses being set up. Although the pharmacologic effect of procaine

should last one to one and one-half hours, the physiologic effect of the anesthetization of the sympathetics lasts a good deal longer, at least twenty-four hours. Generally, two to three daily blocks are sufficient to bring about complete restitution of the process. In addition to procaine blocks of the regional sympathetic ganglia, patients with thrombophlebitis should have their extremities wrapped from the toes to groin and mobilization instituted. This is particularly important in order to prevent a propagating red thrombus proximal to the thrombophlebitic segment. If this is done there is no danger of embolism occurring in the uncomplicated case of thrombophlebitis."

In *suppurative thrombophlebitis*, Ochsner says. "Ligation of the venous system above the site of the involvement is imperative, because if this is not

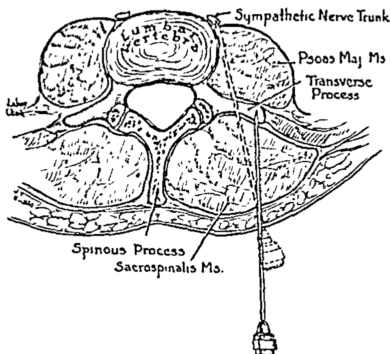


Fig. 102.—Cross section through region of second and third lumbar vertebrae showing course of needle for sympathetic block. Skin wheal is made 4 to 5 cm. lateral to spinous process. Needle is inserted vertically until transverse process is reached, then withdrawn slightly and inserted 4 cm. beyond transverse process until point slides along anterolateral surface of body of vertebra to encounter sympathetic chain. (Nicholson, M. J.: S. Clin. North America 24. 538, 1944.)

done sepsis and fatal pulmonary embolism are likely to occur." (See the section on femoral vein ligation.) Neuhof[127] recommends excision of the infected vein beyond the visible limits of phlebitis.

In 100 cases Stotzer[128] has treated thrombophlebitis without embolism by keeping the patient ambulatory with an elastic bandage on the leg. He believes that the stagnation of blood incident to rest in bed is harmful.[129] Homans[130] says: "Thrombosis once established should no longer be treated by the familiar ice-bag and immobilization but real elevation followed early by gradually increasing exercise. Embolism is more likely to be prevented by forestalling the formation of the dangerous propagating thrombus than by apprehensive immobilization." Heyerdale and his associates[131] emphasize that "a patient who has acute superficial thrombophlebitis does not need

prolonged rest in bed and that rather, even without such rest, he or she can have the offending varicose veins obliterated satisfactorily by a course of treatment very little or no longer than that required for uninvolved varicose veins." Paine and Levitt[132] have found intermittent venous occlusion of

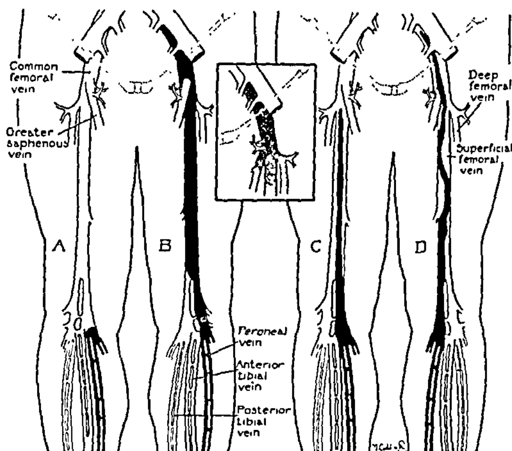


Fig. 103.—Diagrammatic sketches, showing various courses which a deep, lower-leg, quiet thrombosis (phlebothrombosis) may follow. In each case, the disease is shown as starting in one of the three main venous systems of the calf. *A*, The quiet thrombosis is represented as having failed to progress above the popliteal region There is no propagating mass in the popliteal or femoral vein. *B*, The quiet thrombosis has progressed into the femoral vein where it now fully obstructs the femoral and external iliac veins, and is represented as ending cleanly at the junction of the common iliac and hypogastric veins—a present day conception of femoroiliac thrombosis or phlegmasia alba dolens. No attempt is made to indicate the inflammatory reaction about the great vessels or the involvement of collateral channels. (The insert represents an older conception of femoroiliac thrombophlebitis, starting in the region of the groin and spreading distally for an indefinite distance into the superficial femoral vein). *C*, The thrombosis has formed a propagating floating mass, not adherent to or obstructing the femoral vein. Its proximal end might or might not be seen on opening the superficial femoral at the groin. At this stage a fatal pulmonary embolism is seriously threatened. *D*, The thrombosis has reached a fairly advanced stage, being adherent to, without obstructing, the femoral vein and having extended through the left external into the common iliac vein. At this stage, emboli of fair size may readily be detached. (Homans, J.: Surg., Gynec. & Obst 79. 70, 1944.)

value in the treatment of thrombophlebitis of the deep veins of the lower extremity. Tyson and Goodlett[133] say: "When the femoral vein is acutely occluded by a clot, the venous pressure at the ankle is elevated with the leg at rest. If the venous pressure is normal at the ankle or foot after exercise, it may be stated that no massive occlusion of the venous system is present."

The dangers of massage of an extremity affected by thrombosis or thrombophlebitis are well known. Ill advised manipulations of the affected veins have been known to break off thrombi and cause them to float freely in the blood stream and become pulmonary emboli. Cases have been reported in which death has occurred instantly.

Compression bandages are useful.[134] Kappis[135] recommends bandaging from the toes to the groin with adhesive plaster in cases of venous thrombosis.

In *phlebothrombosis* (quiet venous thrombosis) the patient may have no symptoms. Ochsner[124] says the patient "usually has no pain, has little or no fever, and there is usually no swelling of the extremity. We have observed that frequently the patient has a sense of impending disaster. According to Bahls[136] the patient is likely to be restless. There is almost invariably tenderness over the involved vein, and the calf and plantar veins are frequently the original sites. Tenderness in the calf or on the plantar aspect of the foot is of importance. Pain in the calf or popliteal area resulting from dorsiflexion of the foot with the leg extended is of diagnostic importance, as suggested by Homans[137] (*Homans' sign*). Not infrequently there is an increasing pulse rate out of proportion to temperature elevation, which finding has been emphasized by Mahler and DeBakey and me. Mahler described this as stepladder pulse. In a suspected case the determination of the erythrocytic sedimentation rate is of importance, and is probably the result of the alteration of the albumin-globulin ratio."

According to Ochsner:[124] "The treatment of phlebothrombosis in contradistinction to thrombophlebitis is always radical. As mentioned previously, this type of intravenous clotting is accompanied with few or no manifestations. These patients do not appear ill but they represent potential fatalities, because the clot not being attached to the vein wall is likely to become detached and result in a fatal pulmonary embolism. Unless measures are taken to prevent the clot from getting into the systemic circulation after it becomes detached, a tragedy will result. In suspected cases of phlebothrombosis and also in those cases in which a pulmonary infarct has occurred, ligation of the involved vein above the thrombus is imperative. Because in many instances thrombosis is bilateral, it is desirable to do a bilateral femoral ligation. . . . Although we originally contended that it was desirable to expose the vein above the site of involvement and ligate rather than attempt to aspirate the proximal portion of the clot, we now believe that the latter procedure is preferable. Exposure of the femoral vein in the upper part of the thigh can be performed with considerably less operative trauma than exposure of the external and common iliac veins through a retroperitoneal approach. The operation can be done under local analgesia, and can be done in the patient's bed, but is preferably done in the operating room. The patient is placed on the operating table with the trunk on a higher level than the thigh to increase the venous pressure in the femoral vessels. The femoral vein and its branches at its upper extremity are exposed. Care is taken not to manipulate the vein any more than is absolutely necessary, because a thrombus which is frequently difficult to detect before the vein is opened can be easily dislodged. Ligatures are carefully and loosely placed around the common femoral above the saphenous, around the profunda femoris, and around the superficial femoral. The long saphenous is doubly clamped close to the femoral and divided between the clamps. The distal end is ligated and the

edges of the proximal end caught either with mosquito forceps or fine sutures. Into the proximal end a glass suction tube is introduced passing proximally into the femoral and external iliac veins, and gentle aspiration is maintained, in order that a contained thrombus can be aspirated. Aspiration is maintained until a free flow of blood occurs from the proximal portion, indicating an absence of clot between the opening in the saphenous vein and the inferior vena cava. Because of the elevation of the trunk and upper part of the body there will be an increase in the venous pressure and expulsion of the clot is favored. The femoral is then ligated above and below the saphenous opening. If there is free bleeding from the profunda femoris it need not be ligated, but if it also contains a thrombus it is to be ligated as well as the common femoral. By the interruption of the involved vein above the site of the embolism in phlebothrombosis, one can prevent embolism from occurring, and in this way prevent infarction and fatality."

Ligation of the femoral vein in venous thrombosis of the lower extremity has aroused great interest. In many of the large clinics of the country the procedure is not believed in, and reliance is placed upon conservative therapy. Yahr et al.[138] report 67 cases of thrombophlebitis treated by dicumarol only.[139] On the other hand, the preponderance of opinion seems to be that femoral ligation has a distinct place.[140] Moreover, ligation of the common iliac vein and even of the vena cava is advocated under certain conditions. Fine et al.[141] advise "division of the femoral vein for the prevention of embolism in *all* cases of thrombophlebitis of the deep veins of the lower leg." Fine and Starr[142] say: "In a previous communication it was pointed out that fatal embolism has occurred from thrombosis of the vena profunda femoris when it has been spared by ligation of the superficial femoral vein. We persist in this view regardless of how innocuous the profunda may seem, for only a short segment of it can be visualized. The greater likelihood of edema after blocking the common femoral rather than the superficial femoral is a small consideration in view of the greater safety of the former. The selection of the level of ligation is made on the basis of the evidence of the extent of involvement: (a) the common femoral vein is ligated when thrombophlebitis is limited to the veins below the knee or when pulmonary embolism has occurred in the absence of all signs of involvement; (b) the common iliac is ligated when thrombophlebitis involves the common femoral, external, or common iliac veins; (c) the vena cava is ligated when the indications are that both common iliacs require ligation. Since the frequency of bilateral involvement is high, bilateral vein ligation is generally indicated. The occurrence of spastic narrowing or obliteration of venous channels limits the diagnostic usefulness of venography. The distinction between quiet venous thrombosis and full-blown thrombophlebitis, that is, phlegmasia alba dolens or milk leg, is not a dependable means of deciding when a clot is detachable and when it is not. Therefore, exploration of most cases of so-called milk leg is advisable. Early mobilization after operation does not provide full security against the development of thrombophlebitis."[143]

On the basis of 861 femoral vein interruptions at the Massachusetts General Hospital, Allen[144] says that phlebography has been abandoned, that the vein interruption should be bilateral, that ligation of the femoral vein has been done in the majority of cases distal to the profunda femoris (that is, the superficial femoral vein is ligated) and that thrombi are removed by *suction*. There was one fatal embolism from the profunda femoris after ligation of

the superficial femoral vein. Allen and his associates have done prophylactic femoral vein interruptions in 100 cases in which prolonged rest was required, as in fractures of the hip region. De Takáts and Fowler[145] found permanent edema of the leg when the common femoral vein was ligated and prefer ligation of the superficial femoral vein. Their indications for ligation are as follows: "(1) When the patient has had an infarct, wholly unexpected, the source of it is carefully investigated. If it is found to be in the calf muscles of the leg, the femoral vein is promptly tied below the profunda. (2) When the patient develops a recognizable calf muscle thrombus, which has been present for less than one week and the patient is immobilized for some other reason, the femoral vein is tied. Often a floating thrombus will be found in the common femoral vein. When, however, the patient is seen with a tender, swollen thigh or groin, the clot is not aspirated nor is the vein ligated above the profunda. Also, if the thrombus is below the knee but the patient has been ambulatory for more than one week without any extension to the thigh, the vein is not tied."

Linton[146] says: "Femoral vein interruptions have been carried out in over 1000 patients at the Massachusetts General Hospital without a single instance of serious interference with the circulation of the extremity, and the mortality rate from the procedure has been zero."

Veal and Hussey[147] report 84 cases of thrombosis of the deep veins of the lower extremity treated by ligation of the affected veins without a death as a result of operation. They say: "A total of ninety-eight ligations were performed. The sites of ligation were the inferior vena cava (six times), common iliac vein (twenty-nine times), external iliac vein (six times), and femoral vein (fifty-seven times). In forty-five cases in which ligation was performed before the development of pulmonary embolism, there were no instances of this complication. In thirty-nine cases in which the operation was done after at least one episode of pulmonary embolism, there were nine cases of postligation embolism."

The *procedure is favored in Coller's clinic*[148], by Bancroft,[149] who combines it with thrombectomy, by Jensen[150] and by Allen and his associates.[151] Moses[152] has ligated the inferior vena cava in 21 cases and iliac veins in 15 cases, with 13 deaths. O'Neill[153] suggests two indications for interruption of the inferior vena cava, namely, "when concurrent phlebothrombosis exists in both lower extremities and has extended to or above the inguinal ligament; and when pulmonary embolism has occurred and its source is not evident." Dennis[154] reports a disastrous result from femoral vein ligation when there was inadequate collateral venous return and warns against its indiscriminate use.[155]

The technic of division of the superficial femoral vein is described by de Takáts[156] as follows:

"The long saphenous vein is identified and used as a guide to the femoral vein. The fascia lata is entered and, medial to the artery, the vein is exposed; the division of the common femoral vein into superficial and deep femoral veins is identified. Just distal to this division, the superficial femoral is tied with No. 20 cotton and another cotton ligature is placed two fingerwidths below [illegible]
proximal and dist[illegible]
encountered at thi[illegible]
femoral, the ligature must be placed around the common femoral vein." It is often wise to do a bilateral femoral vein ligation.[157]

Fine and his associates[141] consider *venography* to be "an indispensable technic for the correct management of all types of thrombophlebitis of the lower extremity," but they warn that vasospasm must be ruled out in interpreting the venogram. They employ the technic of Bauer,which they describe as follows:[141a]

"The patient lies on his back with a 6 cm. block heel. A 14 by 17 inch *x*-ray film is placed under the leg, its lower edge about 3 inches above the ankle. A small incision is made about 1 cm. behind the external malleolus. A constant small vein is found here which communicates readily with the deep system. Through a fine needle 20 cc. of 35 per cent diodrast* is injected at a uniform rate during a period of sixty seconds. At the end of the injection the exposure is made.

"Resistance to the injection may be notably increased over that encountered in the absence of deep thrombosis. A useful hint of the presence of thrombosis is a decidedly increased caliber of the vein at the ankle. If the foot is held in moderate inversion the shadow of the veins will not be obscured by that of the bones of the leg. The normal venogram shows the deep veins of the calf, the popliteal and the femoral vein well outlined. A few superficial veins also are seen. Thrombophlebitis is characterized by partial or complete absence of filling of the deep veins with the contrast medium. Superficial collateral channels may be evident even in the acute stage, although they are more obvious in long standing deep thrombophlebitis. When the venogram of an extremity is repeated, the identical pattern of normal filling or of a filling defect is reproduced."

Fine and his associates have followed the suggestion of Dougherty and Homans[158] "that the vein be washed out with saline solution after the injection." Homans[159] considers venography with diodrast to be valuable, although he reports a case of thrombosis as a complication. Wagner[160] calls attention to the complications following arteriography of peripheral vessels. He says: "Arteriography of the peripheral vessels is of value in the accurate diagnosis of arterial lesions and the early diagnosis of bone cancer but is not without danger. The risk of complications does not warrant the abandonment of arteriography as a diagnostic aid but rather should keep one alert to minimize the danger by a proper selection of cases, careful choice of contrast material associated with the taking of an allergy history and the performance of a standard sensitivity test, painstaking technic and preparedness for prompt treatment if the necessity arises."

Many surgeons of experience and authority view with some skepticism the procedure of ligation of the femoral and iliac veins and the inferior vena cava, although, as Loewe and his associates[161] say, "it is apparent that the surgical approach, while efficacious in the majority of instances, has its limitations, although in all fairness it must be stated that a great number of lives have been saved which otherwise would have been lost if surgical interruption of the venous systems had not been practiced since no alternative conservative method of management has heretofore been generally available." Loewe and his associates have treated 125 patients with venous thromboembolic disease with subcutaneous heparin in the Pitkin menstruum,† and there were 42 instances of pulmonary embolism with 4 deaths (9.5 per cent). "The ingredients of the Pitkin menstruum are gelatin 15 to 30 per cent, dextrose 5 to 12 per cent, glacial acetic acid 0.5 per cent and sufficient distilled water to make 100 per cent." (Loewe et al.) For the patient weighing 150 lb., 300 mg. of the heparin sodium salt is given as the initial dose. This dose should keep the patient heparinized for two days. Subsequent doses

* Supplied by the Winthrop Chemical Company.

† Roche-Organon, Inc., Nutley, New Jersey.

are governed by the coagulation time and are usually given every two or three days. Loewe and his associates say: "The effect of heparin is judged by and based on determination of the blood coagulation time, which should be done at least once a day during the period of heparinization. Determination by means of the capillary tubes is totally inaccurate and should not be used. A modification of the Lee-White method[162] for determination of blood coagulation time is recommended. The procedure is as follows: 1. Place four chemically clean dry 75 by 10 mm. test tubes in a rack. 2. With a sterile dry syringe and needle withdraw a little less than 2 cc. of venous blood from the heparinized patient. 3. Distribute a little more than 0.35 cc. of blood into each test tube and allow the tubes to stand until the test is completed. 4. The test is timed by stop watch from the moment the vein is negotiated to the time clotting is noted in the test tubes. The normal values usually range from nine to fifteen minutes."

Evans and Boller[163] say: "For the past three and a half years postoperative venous thrombosis has been treated at the Lahey Clinic largely by anticoagulation therapy. For the last two and a half years femoral section and ligation have been reserved for cases of ambulatory recurrent calf phlebothrombosis with one or more benign pulmonary emboli or postoperative cases in which a second stage operation must be carried out. So far there have been one death from pulmonary embolism and four recurrent benign pulmonary emboli in 125 cases so treated. This death occurred early in the series after anticoagulation therapy had been needlessly abandoned to treat anemia with a transfusion." These authors conclude: "Heparin/Pitkin is a gelatinous-based material that contains the heparin sodium salt with or without vasoconstrictors (epinephrine and ephedrine). It is available in 1 cc. and 2 cc. ampules containing 100 mg. and 200 mg. respectively and is administered subcutaneously. Patients of less than 150 pounds receive 200 mg.; those weighing more than 150 pounds are given 300 mg. Subsequent dosages depend on the individual response as measured by clotting time. Of 18 patients treated with heparin/Pitkin for thrombotic emergencies or for prophylaxis 16 were given Dicumarol (3,3'-methylene-bis-[4-hydroxycoumarin]). Nine patients received heparin/Pitkin without vasoconstrictors. In this group the onset of effect when measured on time took place within one and a half hours. The maximal effect ranged between twelve and twenty hours. The average duration of effect in these cases was forty-one hours. Nine patients were given part of their dose of heparin/Pitkin with vasoconstrictors. The onset of effect and maximal effects were similar to those obtained with the first group of patients. The average duration of effect was sixty-one hours. The longest responses were obtained by using the heparin/Pitkin combination of 200 mg. with vasoconstrictors and 100 mg. without vasoconstrictors. A case was encountered which demonstrated that heparin/Pitkin exerts an adequate anticoagulation effect in the latent period before Dicumarol is effective. The possible side effects from heparin/Pitkin are trivial."

Further testimony in behalf of heparin therapy in acute deep venous thrombosis comes from Sweden. Bauer[164] says: "Investigations going on since 1938 and consisting in phlebographic examinations on nearly 600 patients, as well as coordinated clinical observations, gave evidence that acute thrombosis of the deep veins of the leg practically always (in 98 per cent) begins in the calf veins and from there propagates in the cranial direc-

tion. This knowledge makes possible a very early diagnosis of incipient thrombosis. At the least suspicion the examination can at once be directed toward the lower part of the leg. The clinical signs of thrombosis there are now becoming known. The diagnosis should if possible be verified by phlebography. As soon as the diagnosis has been made, treatment should be instituted. The method that I introduced consisted in giving these patients an intensive heparin treatment. Forceful active leg movements were insisted on from the first day. The patients were made to leave bed one day before the heparin cure was terminated. This plan of treatment was followed for more than five years; 209 cases of acute deep leg thrombosis were treated. There was no death from postoperative pulmonary embolism. Three fatal cases were recorded among the patients not operated on; 206 cases were cured. In these, fever, leg swelling and pain disappeared so rapidly that the

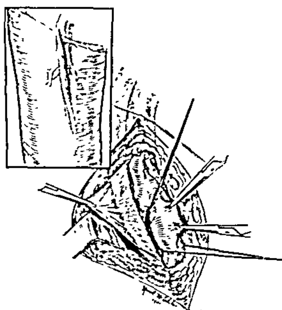


Fig. 104.—Division of femoral vein. The superficial femoral vein is exposed, and control guy ligatures are passed above and below the site in which the vein is to be opened. (Welch, C. E., and Faxon, H. H.: J. A. M. A. 117: 1502, 1941.)

patients were able to leave bed after, on an average, 4.7 days." Long et al.[165] made studies of the effect of heparin on the prothrombin time and concluded: "First, the prothrombin time may be definitely prolonged by 50 mg. of heparin administered intravenously; second, both this effect and the effect on the coagulation time usually have subsided by the end of three hours."[166]

Lesser[167] recommends pressure dressings on the lower extremities as an additional measure in the prevention and treatment of thromboembolism.

The treatment of phlebitis by leeches was revived by Terunier[168] in 1922. This author reported 19 cases in which there was early improvement after the leech treatment. Mahorner and Ochsner[169] obtained excellent results in 3 cases. These authors say that "the good effects of the leech treatment of phlebitis are: (1) rapid disappearance of pain, (2) disappearance of tenderness, (3) subsidence of edema, (4) when the thrombosis is not too long standing, the clot softens and objective evidence of its presence disappears, (5) fever

subsides, (6) the duration of phlebitis is shortened, (7) the danger of pulmonary embolism is markedly decreased "

In discussing the management of acute thrombophlebitic edema, de Takáts[170] says: "In order to accomplish a rapid disappearance of thrombophlebitic edema in the lower extremities, the following principles of treatment are systematically employed: (1) maximal elevation of the affected limb; (2) restriction of fluid and salt intake, and (3) repeated injections of a mercury diuretic, salyrgan, with adequate premedication. Later, gradual exercise and massage are started, the object now being to prevent reformation of the edema. This management, however, is effective only at the time when the edema appears and is hardly effective in the chronic, irreparable stage of fibrosis. Further trial in a large series of cases is desirable."

Recently there has been much interest in *thrombosis due to effort*. In these cases trivial trauma is followed by vasospasm with sensory disturbances of the upper extremity. Lehman[171] reports 4 cases: One patient recovered following fever therapy with mixed typhoid vaccines; another recovered following fever therapy, the third recovered following excision of an inflammatory nodule over the olecranon process and for the fourth patient, amputation was considered, but recovery followed periarterial sympathectomy. Paggi[172] collected reports of 74 supposed cases from the literature In Huard's[173] case recovery followed resection of the thrombosed section of vein and denudation of the artery. Kaplan[174] says: "The diagnosis of primary axillary thrombosis is made on the following symptoms and signs: 1. Swelling of the arm and cyanosis within several hours or days after the accident, injury by strain or, occasionally, without any cause. 2 The absence of a rise in body temperature and absence of signs of local active inflammation 3 The presence of dilated superficial veins on the affected arm and over the anterior part of the chest and also in the axilla. 4. The delay or absence in the collapse of the superficial veins of the upper extremity when the latter is raised above the heart level. 5. The presence of a cord in the axilla, which need not always be tender. 6. The increase of the venous pressure in the affected extremity. 7. Prolongation of the circulation time in the affected arm. 8. x-Ray visualization of new collateral formation, enlargement and dilatation of the veins, evidence of stasis, on injection of radiopaque dyes into the veins of the affected arm, and the failure of the axillary vein to be visualized. 9. The presence of numerous superficial veins on the affected side as shown by photography with the infra-red technic. . . . In the acute stage the treatment consists of rest, elevation and hot moist packs locally. If there is residual edema, an elastic bandage may be applied spirally, beginning at the hand and extending upward to the shoulder. Diathermy is of value in reducing the swelling. In obstinate cases, excision of the thrombus or the entire segment of the thrombosed vein has been recommended. However, the advisability of such procedures is questionable, since after removal of the thrombus recurrence is likely, and if the venous segment is resected the chance for canalization of the organized thrombus is lost. . . . Prognosis as to life is good. The duration of the disability is variable. Patients may be completely restored in from one to two months and in many cases the convalescence is prolonged because of edema, weakness and stiffness of the arm. Recurrences are occasionally noted following exertion." This condition may have medicolegal importance. It is fully and authoritatively discussed by Matas[175] who concludes:

"1. That the so-called 'axillary thrombosis by strain or effort' is a complex syndrome of [illegible] iron- [illegible] role, [illegible]

"2. That the vascular reactions (edema and signs of venous obstruction) and functional disability, which are peculiar to this disorder, are usually out of all proportion to the extent and degree of the trauma.

"3. That none of the theories at present advanced to explain this condition is adequate *singly* to account for all the clinical phenomena that constitute the classical type of this affection.

"4. That a difference should be recognized medicolegally between primary spontaneous thrombosis of the axillary vein caused by accidental trauma (muscular strain and indirect injury) and so-called spontaneous thrombosis which occurs without any history of accident or antecedent injury or continued occupational strain. The absence of accidental trauma, whether direct or indirect, trivial or severe, excludes *ipso facto* the nontraumatic cases from the category of accident insurance liabilities.

"5. In all cases which resist the classical method of treating thrombophlebitis, an explora-

tory operation is indicated to uncover the nature of the lesion and remove it by *thrombectomy* when the clot exists, or by the excision of the venous segment when this is obviously diseased, even though no clot exists."

De Takáts[176] advises the injection of ½ grain of *papaverine hydrochloride* to overcome vascular spasm accompanying trauma or thrombosis of major arteries.[177]

Horton,[178] of the Mayo Clinic, reports a case of *primary thrombosis of the axillary vein* Apparently a cure was obtained in this case by elevating the arm for several days and after that wearing a rubber bandage for about a year.[179]

Thromboangiitis obliterans (Buerger) is an obliterating disease of the arteries. This disease is accompanied by pains in the soles of the feet, by intermittent claudication (severe pains in the calves of the legs induced by a small amount of exercise and disappearing with rest), coldness and numbness of the feet, redness of the toes and finally disappearance of the pulses.

Theis and Freeland[180] state: "In a series of 7 cases of acute thromboangiitis obliterans in which the superficial venous blood from the involved extremity could be studied, we found increased viscosity of the blood, rapid sedimentation of the cells, rapid coagulation, greatly increased alkalinity, low or normal cell counts and arterial oxygen saturation and a low carbon dioxide content of the blood."

Graves[181] states that the stage of the disease should determine the treatment:

"1. Extensive gangrene with or without pain. The treatment is high amputation

"2. Severe 'rest pain' with or without moderate trophic changes. The treatment consists of measures for relief of pain, methods to increase circulation, removal of foci of infection, and, in a limited number of cases, lumbar ganglionectomy and ramisection may relieve pain and increase circulation. If these measures fail, amputation is indicated.

"3. Mild trophic changes without 'rest pain.' The treatment should be designed to increase circulation. Foci of infection should be removed and prolonged rest enforced. Lumbar ganglionectomy and ramisection are of value in certain cases.

"4. Neither 'rest pain' nor trophic changes. The treatment consists of rest, removal of foci of infection and conservative measures to increase circulation.

"Cessation of smoking is indicated in all cases as its vasoconstricting action prevents a maximum development of collateral circulation. The removal of foci of infection is advisable in all cases to improve the general condition of the patient.

"Avoidance of excessive exercise, wearing of tight shoes, exposure, and trauma are indicated to lessen the occurrence of trophic changes."

Theis and Freeland[182] say: "The way smoking acts as a contributing or as an exciting rause is not known, but it is essential for the success of treatment and the avoidance of cecurrences that smoking be discontinued."

Adson and Brown[183] treated 100 consecutive patients with thromboangiitis obliterans by sympathectomy. Improvement occurred in 87 instances. De Takáts[184] says: "The value of sympathectomy in a variety of peripheral vascular disorders is definite. The operation insures an even bloodflow to the denervated extremity because its vessels do not respond to central or reflex stimuli and all the available blood can serve to nourish the tissues. Selected cases of Raynaud's disease, Buerger's disease, poliomyelitis with vasospasm, causalgic states, acute emboli and thromboses, aneurysms and hyperhydrosis have been subjected to sympathectomy. The technique of sympathectomies for the upper and lower extremities is now developed to a point where permanent sympathetic denervation can be expected. These operations should now be regarded as being past the experimental stage and should play an important part in the treatment of peripheral circulatory disturbances." *Brown[185] contends that "adequate medical treatment will* control pain and cause healing of ulcers in 80 per cent of cases."

The author has been very favorably impressed with the work of Samuels[186] and has used his method with success. Samuels has treated over 300 patients with thromboangiitis obliterans with only one leg amputation. His treatment comprises: (1) rest in bed, (2) prohibition of smoking, (3) *intravenous injection*



Fig. 105.—Massive gangrene of the right foot. (Samuels, S. S: J. A. M. A. 102: 436, 1934.)



Fig. 106.—Appearance of the feet after healing of the ulcer. (Samuels, S. S.: J. A. M. A. 102: 436, 1934.)

every other day of 300 cc. of 2 to 5 (generally 3) per cent of sodium chloride solution and (4) surgical cleanliness of the ulceration and of gangrenous areas (Figs. 105, 106).

Of great importance in the treatment of peripheral obliterative arterial disease is the employment of passive vascular exercise by the *pavaex apparatus*

of Herrmann and Reid.[187] By means of this apparatus[188] 80 mm. of mercury negative pressure is alternated with 20 mm. of mercury positive pressure every fifteen to thirty seconds. Four to 5 twenty minute treatments are given daily in the hospital until the circulation is improved. A simplified apparatus for this purpose has been devised by Short.[189] Herrmann and Reid gave 3769 treatments to 51 patients; 86.2 per cent were greatly benefited, and these workers believe "that treatment with the pavaex unit (passive vascular exercises) is the most effective means of bringing about the development of an adequate collateral circulation in the extremities of patients with extensive organic obliterative arterial disease."[190]

Reid and Herrmann[191] have had an experience with pavaex therapy of 16,000 hours of treatment, and reference should be made to their various papers for the carefully presented details of the treatment. Bernheim[192] calls attention to the importance of the intelligent use of the pavaex treatment

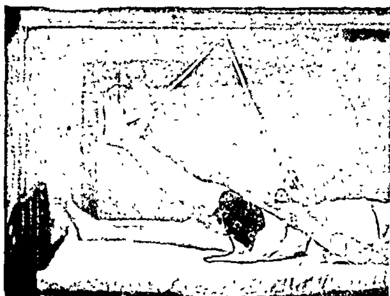


Fig. 107.—Apparatus in use. For the home, the pulley can be screwed into a door jamb, or a wooden frame can be constructed (de Takáts, G.; Hick, F. K., and Coulter, J. S.: J. A. M. A. 108: 1951, 1937.)

and reports an amputation in a woman 61 years of age following its use. Shipley and Yeager[193] report favorable results with this form of treatment in thromboangiitis obliterans, obliterative arteriosclerotic disease, frostbite gangrene, ununited fractures and arthritis.

De Takáts, Hick and Coulter[194] have found *intermittent venous hyperemia treatment* to be of value in peripheral vascular disease. In this method (Fig. 107) the leg is passively elevated for one minute, a wide blood pressure apparatus cuff placed high on the thigh is inflated to 40 to 90 mm. of mercury (not to exceed the diastolic pressure) for two minutes, and then the pressure is released and the leg lowered to horizontal for three minutes. One minute of compression, one minute of release and one minute of elevation are prescribed if the circulatory embarrassment is more pronounced. Thirty minutes of this treatment is given twice a day. This method is similar to that of intermittent venous occlusion, which gave such good results in the hands of Collens and Wilensky.[195]

Murray and his associates[196] conclude that in "extremities with impaired circulation the best prospects for survival can be provided by keeping the extremity dependent, by the application of cold, and by using methods to effect maximum dilatation of the collateral vessels entering the extremities."

Theis and Freeland[197] say "The clinical results in the treatment of the biochemical blood changes in acute or active thromboangiitis obliterans with sodium tetrathionate or sodium thiosulfate and of the peripheral circulatory deficiency due to arterial thromboses with pavaex treatment have been most encouraging."[198]

McNealy and Shapiro[199] have made a careful study of the criteria for amputation in vascular disease of the lower extremities. Of first importance is the estimation of the circulation status of the limb. "Amputation need not always be done at or above the knee in Buerger's disease." Neller and Schmidt[200] have used wheal-fluorescence in evaluating the circulation in peripheral vascular disease. Perlow[201] says that alcohol nerve block (through skin incisions) in peripheral circulatory diseases of the feet will give relief from pain lasting three to six months. This author also advocates local diathermy.[202]

Barker[203] has sounded an important warning in regard to the great danger of gangrene of the toes in thromboangiitis obliterans and arteriosclerosis obliterans. He says: "In cases of peripheral occlusive arterial disease, the toes are extremely vulnerable and gangrene may easily be induced by even mild degrees of injury. In a series of 171 cases in which gangrene was associated with thromboangiitis obliterans the gangrene followed therapeutic procedures on the toes in 60 (35 per cent), and in a series of 115 cases in which the gangrene was associated with arteriosclerosis obliterans, the gangrene followed therapeutic procedures in 45 (39 per cent). These procedures consisted chiefly of removal of ingrown toenails; less commonly they consisted of removal of corns, incisions for suspected abscesses, thermal burns, and irritations resulting from the application of strong chemicals or exfoliating ointments. Pain in the toes may result primarily from ischemia, even when there is an obviously deformed nail, or a corn. It is strongly recommended that no local surgical or medical treatment of toes be instituted in any case until the arterial blood supply has been proved adequate by palpation of pulsations in the posterior tibial and dorsalis pedis arteries, and by the absence of abnormal color changes in the elevation dependence test. If arterial insufficiency is demonstrated, local treatment of painful toes should be extremely conservative, and all possible trauma should be avoided." Barker[204] believes that foreign protein therapy is rational in the treatment of thromboangiitis obliterans, particularly in cases in which there is rest pain, with or without ulcers or limited gangrene.

Arteriosclerosis.—"Arteriosclerosis of the peripheral arteries is a degenerative disease of advancing age, characterized by diffuse narrowing and inelasticity of the vessels, resulting in ischemia, which affects chiefly the lower extremities. The process progresses slowly, although sudden thrombotic occlusions may be induced by trauma, exposure or infection. Collateral vascular channels are sparse because of the diffuseness of the lesion and the impaired reparative powers of these aging patients. The slow progression of the disease

ischemia, severe pain, trophic ulceration, infection and impending or beginning gangrene, circulatory balance may again be restored. If not, spreading infection or massive gangrene may leave no alternative to amputation."[205]

Glasser and Lesser[206] report favorable results from femoral vein ligation in 20 patients with occlusive arterial disease of the lower extremities. de Takáts and Miller[207] say "By the use of an improved plethysmograph, data have been obtained which show that in different grades of arteriosclerosis approximately as much increase of blood flow can be obtained by applying indirect heat as by applying a heat cradle directly to the affected extremity. Because direct application of even a moderate amount of heat may lead to increase in pain and acceleration of gangrene, a plea is made never to apply direct heat to any ischemic limb. A heat cradle may be safely and effectively applied to the root of the limb and the abdomen proximal to the level of impaired circulation. Directions for the construction of such a cradle are given."[208]

Raynaud's disease is a vasomotor neurosis which occurs in young adults and is marked by cold, capillary congestion (cyanosis) and eventually

gangrene without vascular occlusion. Raynaud's disease may be related to psychic exertion, trauma or exposure to cold. The disease, which is symmetric, is characterized by tingling pain, an intermittent course, anesthesia and first whiteness and then blueness. It generally involves the fingers.

Allen and Brown[209] conclude: "The requirements for the diagnosis of Raynaud's disease are: (1) intermittent attacks of discoloration of the acral parts, (2) symmetrical or bilateral involvement, (3) absence of clinical evidence of occlusive lesions of the peripheral arteries, (4) the limitation of possible gangrene or trophic changes largely to the skin, (5) the presence of the condition for at least two years, (6) absence of organic disease to which the vasomotor changes might be secondary, and (7) greater frequency of the condition in females than in males."

To date there has been no satisfactory treatment for this ailment. The best hope for the alleviation of the symptoms of Raynaud's disease probably lies in completely performed sympathectomy.[210] Kraetzer[211] reported a case of Raynaud's disease which he believed to be caused by arsenic and in which improvement followed treatment with sodium thiosulfate.

In his interesting article on Raynaud's disease, Graves[212] says that "therapy in Raynaud's disease aims only at a symptomatic cure. Mild cases which are more common probably do best without any treatment other than the institution of prophylactic measures. The wearing of warm loose gloves, soft woolen stockings, and adequate clothing usually suffices to minimize the frequency of attacks. Removal to warm, even climates has proved beneficial in not a few cases. Attacks may be aborted or shortened by the application of heat. If these cases do not progress in two years, they probably never will; but should they become more severe, more energetic measures are indicated.

"Repeated galvanic hand and foot baths of ten minutes' duration have seemed to help some few; but results equally satisfactory may be expected from the production of hyperemia by Bier's method or by the use of an elaborate apparatus designed to produce a negative pressure about the affected part. Cushing advocated the application of a semi-elastic bandage, just tight enough to constrict the venous return from the part. This may prove beneficial, but pain is intensified.

"Amyl nitrate and nitroglycerin have quite naturally been given a trial by many, but there are no reports of either's ever having been of constant benefit.

"Various endocrine gland extracts have been vaunted as of exceptional value, but like all other conservative measures they have fallen into disuse in uncomplicated Raynaud's disease.

"Recently Brown and Adson have reported distinct benefit in some few cases from the production of a febrile reaction by the injection of nonspecific proteins. A vasomotor paresis is thought to result from fever.

"Certainly conservative treatment as outlined has only occasionally proved satisfactory. Those cases not destined to remain mild have progressed in spite of treatment and, because of this, more radical measures were sought, and these are now fast becoming standardized.

"Small areas of gangrene should be allowed to demarcate and slough, as healing by cicatrix may be expected. Large gangrenous areas are best amputated to save time and free the patient of pain."

[illegible] nor surgery [illegible] rupture of [illegible] wrist which [illegible]

careful examination will differentiate this transmitted pulsation from a true expansile pulsation." Ligation of the vessel proximal and distal to the aneurysm is indicated.

Erythromelalgia and Scleroderma.—Erythromelalgia is an ailment characterized by pain, redness, swtlhloefigne feet and hyperesthesia. The arterial pulsation is present. Scleroderma

has been described as "a disease of the skin in which thickened, hard, rigid, and pigmented patches occur." (Dorland.)

Immersion Foot.—For information regarding immersion foot, reference should be made to articles by Fausel and Hemphill[214] and by White.[215]

GANGRENE*

Diabetic Gangrene.—Root[216] believes that if infection and trauma were excluded, death from diabetic gangrene would disappear. The control of the diabetes is of primary importance in the prophylaxis of gangrene and as the foundation for successful surgical treatment. The immediate causes of gangrene are preventable according to Root. Cutting of corns, blisters and minor foot injuries all play a role. Root believes that it is most important to educate every diabetic patient in the care of his feet. Every patient leaving the New England Deaconess Hospital is furnished with the following instructions:

"*Hygiene of the Feet.*—1. Wash the feet daily with soap and water. Dry thoroughly, especially between the toes, using pressing rather than vigorous rubbing.

"2. When thoroughly dry, rub well with hydrous wool fat as often as necessary to keep the skin soft, supple, and free from scales and dryness, but never render the feet tender.

"3. If the feet become too soft, rub once daily with alcohol.

"4. If the nails are brittle and dry, soften by soaking in warm water one half hour each night and apply hydrous wool fat generously under and about the nails, and bandage loosely. Clean the nails with orange-wood sticks. Cut the nails only in a good light and after a bath, when the feet are very clean. Cut the nails straight across to avoid injury to the toes. If you go to a chiropodist, tell him you have diabetes.

"5. Wear shoes of soft leather that fit and are not tight (neither narrow nor short). Wear new shoes one half hour only on the first day and increase the period one hour daily.

"6. Do not step on the floor with bare feet.

"7. Use bed socks instead of hot-water bottles, bags or electric heaters.

"*Treatment of Corns and Callosities.*—1. Wear shoes that fit and cause no pressure.

"2. Soak the foot in warm, not hot, soapy water. Rub off with gauze or file off the dead skin on or about the callus or corn. Do not tear it off A corn may be painted with the following mixture: Salicylic acid, 1 drachm; collodion, 1 ounce. Repeat for four nights; then after soaking in warm water the corn will come off easily. If it does not come off easily without bleeding, repeat the treatment for four nights.

"3. Do not cut corns or callosities.

"4. Prevent calluses under the ball of the foot.

"(*a*) By exercises, such as curling and stretching the toes twenty times a day.

"(*b*) By finishing each step on the toes and not on the ball of the foot."

Saunders[217] concludes that: "(1) the severity of infections in patients suffering from diabetes is probably due to the enhanced growth of glycophilic organisms in tissue abnormally high in glucose and with a *p*H most favorable to toxin production. (2) Ninety per cent of the diabetic patients requiring surgery are over fifty years of age and are suffering from complications much more severe than diabetes. (3) Maintaining a low blood sugar with resultant low tissue sugar and change of tissue *p*H helps considerably in controlling the existing infection when conservative surgery is attempted. . . ."

McLaughlin[218] found diabetic gangrene in 53 out of 802 patients admitted to the hospital.[219]

Buerger believes that this condition more properly should be called arteriosclerotic gangrene with diabetes. The prognosis is not unfavorable if appropriate treatment of the diabetes is instituted. Care must be taken to prevent infection, and postural treatment should be given for the arterio-

* See also sections on Thromboangiitis Obliterans, Raynaud's Disease and Gas Gangrene.

sclerosis. While insulin has robbed diabetes of much of its distressing surgical complications, it cannot be expected to aid much in limiting gangrene.[220]

An abscess should be widely opened. It should then be packed with a generous amount of carbowax containing sulfathiazole and sulfadiazine (See *section on Open Wounds*) and covered with petrolatum gauze and a large dressing. The dressings are changed infrequently (every seven to ten days). Glasser et al.[221] have had excellent results from injecting 50,000 units of penicillin into the femoral artery and afterward applying a blood pressure cuff tourniquet for ten minutes.

Meleney[222] advises the use of zinc peroxide, and Samuels[223] advises the use of azochloramide in diabetic gangrene. Brandaleone[224] has had marked success in the direct application of cod liver oil on ulcers of the feet of patients with diabetes. After his routine care of the foot, it is dried and gauze saturated with cod liver oil is applied directly to the ulcer and kept in place with a noncompressing bandage. In 20 of 21 cases the ulcer healed completely in an average time of 10.1 weeks.

Pearse[225] recommends vein ligation as part of the treatment of diabetic (and arteriosclerotic) gangrene. Eliason[226] stresses the importance of preoperative treatment in diabetic gangrene. Seifert[227] points out that after the necrosis has become moist, no more time should be lost with desiccating treatment or minor operations.

The use of refrigeration combined with vasodilatation to preserve vitality in a relatively ischemic extremity is thoughtfully discussed by Ochsner.[228]

Embolic and Thrombotic Gangrene.—Embolism or thrombosis may cause sudden occlusion of an artery with resultant gangrene. Heart disease is the commonest cause of embolism and arteriosclerosis of thrombosis.[229]

Traumatic Gangrene.—Partial or complete subcutaneous rupture of an artery has been known to occur following a relatively slight external trauma or following fractures or dislocations. Gregora[230] reports 4 cases in which subcutaneous rupture of a principal vessel led to gangrene of an extremity. The diagnosis is often very difficult, yet early diagnosis is of the first importance. Absence of the peripheral pulse does not prove that rupture has occurred, as it may be due to a hematoma. Moreover, the peripheral pulse may be maintained in incomplete rupture. Valuable symptoms, according to Gregora, are disturbances of sensitivity and motility of the extremity. The treatment must aim at providing favorable conditions for establishment of a collateral circulation. The injured vessel must be exposed and ligated, if vascular suture is not possible. Trauma may cause a transitory segmental arterial spasm with symptoms of impending gangrene of the extremity distal to the spasm.[231] In these cases the vessel must be exposed to make certain that it is not torn. In the spastic cases recovery generally occurs spontaneously. Gangrene not infrequently follows fractures.[232]

Chemical Gangrene.—Necrosis of the skin has been caused by wet dressings of dilute solutions of phenol, bichloride and even aluminum acetate. They *never* should be employed in the treatment of infections. Prolonged spraying of fingers with ethyl chloride to produce anesthesia for the incision of infections has caused gangrene. Unskilful injections of salyarsan and hypertonic dextrose solution so that the solution is extravasated outside the vein has caused localized sloughing and necrosis. Grolnick[233] reports a case of early gangrene of the hands following repeated immersions in oxalic acid.

Juvenile Gangrene.—Martin and Shore[234] report 4 cases of gangrene of the lower extremities in patients 4½, 6, 7 and 14 years of age, respectively. They discuss the reported cases and state that "the autopsy findings show that, according to the etiology, the cases of gangrene reported may be divided in four groups: (1) Those in which the gangrene followed an embolus, the primary thrombus being in the heart or aorta; (2) those in which there was a primary thrombus in one of the large vessels supplying the extremity; (3) those with evidence of local arteritis in the vessels above the gangrenous area; and (4) those in which no change could be found in the vessels up to the line of demarcation and there was, presumably, a capillary thrombosis which had passed on to massive tissue death

"To account for certain cases of gangrene the influence of infection on the occurrence of thrombosis in the heart, large vessels, and capillaries must be studied. The influence of toxins on the endothelial lining of vessels, sluggishness of the blood stream with the deposition of blood platelets, spasm of vessels, and blocking of the circulation by emboli or thrombi may play a part in the development of this condition.

"In nearly all of the reported cases the gangrene occurred during the terminal stages of a generalized infection or after such an infection.

"Experiments by the authors on rabbits showed that the minute vessels of the extremities can be so altered by the local injection of adrenalin combined with intravenous injections of streptococci that capillary thrombosis followed by gangrene occurs. Spasm with diminished blood supply to the part predisposed to infection." (See Infectious Gangrene.)

Schumm[235] believes that juvenile gangrene is becoming more frequent. He says that the etiologic factor is uncertain and that the only treatment is amputation.

Stapf[236] reports 11 cases of juvenile gangrene and says that in most cases the condition had been present over a period of many years. He considers an important etiologic factor to be mechanical overstrain, particularly of the lower extremities.

Bed Sore (Decubitus).—Bed sores occur in patients with prolonged illnesses; in relatively robust individuals they may occur as the result of unskilled nursing care. In debilitated patients and particularly in those who are paralyzed, it may be impossible to prevent bed sores even with the most faithful care. The prevention of bed sores is best effected by frequent changes of the patient's position, by scrupulous cleanliness of the skin, by washing with alcoholic solution in an effort to harden and toughen the epithelium and by use of an air mattress. High protein diet is important.[237] Astley[238] recommends the use of a sponge rubber mattress. If bed sores are imminent, in addition to this treatment dusting with a powder composed of

Pulv. camph	℥ij
Amyli	℥j
Pulv. zinci oxidum	℥iiss

is very beneficial. Love[239] recommends 5 per cent silver nitrate in distilled water or a mixture of alum, 30 grains; water, 250 cc., and alcohol, 250 cc. The latter is applied several times a day.

Fantus[240] recommends the following:

"℞ Zinc stearate	5.0
Tincture of benzoin	5.0
Scarlet red ointment 5 per cent	0.25
Hydrous wool fat	30 0
Liniment of camphor	180.0
Mutton tallow	500.0

Sig. Melt the fats, add camphor liniment; when mixture is almost cooled, beat in tincture of benzoin and zinc stearate until a creamy mixture is secured."

If bed sores actually have occurred, the best results in the treatment are brought about by avoidance of pressure, cleanliness of the surrounding skin, antisepsis of the ulcer and dry applications, as the aforementioned dusting

powder, and sterile gauze. Latimer[241] has had excellent results in the treatment of bed sores with a freshly prepared 5 per cent solution of tannic acid. Carty[242] has used elastic adhesive plaster successfully in 10 cases. Cod liver oil is often very useful in the treatment of large open bed sores. McCormick[243] urges the administration of thiamine and ascorbic acid.[244] When the inflammation surrounding the ulcer is marked, hot boric fomentations may be necessary.

White and his associates[245] treated 5 patients with bed sores and spinal cord injuries by means of total excision and plastic closure. Penicillin was started twenty-four hours before the operation. They say: "The area excised includes the skin edges and the walls of the ulcer out to normal subcutaneous fat. At the base an attempt is made to remove only the contaminated upper

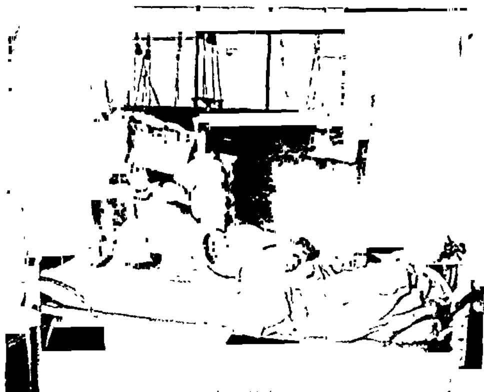


Fig. 108.—Wounded soldier, 1918. Paraplegia from gunshot wound of the spine. Large bed sores over both trochanters. Treatment by suspension. (Author's case at American Red Cross Hospital No. 2; Paris; Dr. Joseph A Blake.)

layers of granulation tissue, and whenever possible not to expose the periosteum and ligamentous tissue over the sacrum. To close the wound made by excising a large sacral decubitus ulcer, it is necessary to undermine wide flaps out into each gluteal region, and transverse incisions must be made in order to slide in lateral flaps. In smaller (5 cm.) lesions, the entire area may be excised with an elliptical transverse incision which follows the natural cleavage lines of the skin and keeps the incision as far away from the contaminated anal area as possible. In cases of transverse myelitis, an anesthetic is usually unnecessary.

"Certain other minor technical points have been found to be of value. No nonabsorbable suture material should be buried, and only a minimum of fine catgut. Electrocoagulation is the method of choice for dealing with small

bleeding vessels. Wide retention sutures of fine stainless steel tied over large buttons (small buttons tend to cut through the skin after a few days) and No. 7 neurosurgical silk for the skin edges constitute the best type of suture material. Approximately every third cutaneous stitch should be placed as a vertical mattress suture, and should include a deep area of subcutaneous tissue to ensure wide approximation of the edges of the flaps with a minimal dead space. These must be tied without undue tension. No drainage is used. The incision is then covered with a 1-inch thick pad of sterile gauze and cotton waste, and taped transversely with adhesive to draw the buttocks together, thereby reducing lateral tension.

"During the first week of convalescence the patient must remain off his back and mostly in a prone position. If he does not have an indwelling urethral or suprapubic catheter, and is not able to control all leakage of urine, a Foley type catheter should be inserted in the bladder to keep the bed dry. Fecal



Fig. 109.—Noma. (Children's Memorial Hospital, Chicago. Courtesy of Dr. Joseph Brenneman)

contamination is prevented by a liquid and very low-residue constipating diet with sufficient paregoric to prevent any movement of the bowels over this period. Unless special circumstances arise, the first dressing is not done until the seventh day, when about one-half the sutures are removed, the remainder being left for another 10 days or longer."[246]

Eiselsberg[247] attributes to von Langenbeck (1855) the first employment of a water bed for bed sores. The patient is placed in the water at a proper temperature and once weekly is placed in a dry bed for twenty-four hours. While with the American Expeditionary Force in France, I treated a soldier with very severe bilateral bed sores over the great trochanters by vertical suspension of both legs (Fig. 108).

Of great interest in the treatment of bed sores is the employment of insulin for nondiabetic patients, as recommended by Joseph.[248] He reports 5 cases in which the administration of 10 to 15 units of insulin daily to nondiabetic patients seemed to bring about rapid cure.[249]

Noma is a microbic, gangrenous stomatitis which occurs generally in children under 10 who are in a debilitated condition (Fig. 109). One half of the cases follow measles. Seventy-five per cent of the cases are fatal in ten days to two weeks. The accepted treatment at the present time consists in radical excision of the affected area with the actual cautery. Ponomarev[250] obtained good results from blocking the sympathetic nervous supply by injecting from 50 to 80 cc. of a 0.25 per cent solution of procaine with epinephrine into the lumbar segment of the left and right sympathetic trunk alternately. From three to four injections were administered at intervals of from three to five days. Shortly after administration of the first injection the patient's general condition improved and spread of the ulcer was arrested.



Fig. 110.—Gangrene of the hand following the use of ergotamine tartrate (Kenney, F. R.: *New England J. Med. 235. 35, 1946*)

As the treatment progressed, the necrotic tissues sloughed away, and healing progressed to a complete cure. Duhail[251] reports a case of noma following early thermocauterization and antigangrene serum therapy.

Gangrene Due to Ergotamine Tartrate (Gynergen).—Zater and Cahill[252] report the case of a middle-aged woman who had gangrene of both lower extremities immediately after the institution of ergotamine tartrate (gynergen) therapy. They suggest that "the use of drugs of this type be avoided in cases of vascular disease such as atherosclerosis, Buerger's [illegible] ...onary arteries."
[illegible] ...tamine tartrate

Arteriosclerotic Gangrene. (See Arteriosclerosis.)

EXPOSURE TO COLD

Prolonged exposure to intensely cold air, solutions, or solids may cause the freezing of the tissues (*frostbite*). In the severe cases gangrene will result. In the mild cases of repeated exposure to cold, *chilblains* (*acute perniosis*) will result. Local tissue necrosis may be caused by an ice bag.[254] Most of the cases occur in the first two decades. The skin assumes a violet-red color, and swelling and numbness of the part develop. On the first exposure to cold and with repeated exposures, constant burning and itching result (chilblains). Frostbite may injure the joints.[255] Lange and Boyd[256] have found the fluorescein test to be valuable in the prediction of tissue loss. In experimental animals heparin was helpful in the prevention of gangrene. Lange and Loewe[257] found heparin in the Pitkin menstruum to be of value in experimental human frostbite. Intravenous procaine hydrochloride (20 cc. of a 1 per cent solution, repeated once in twelve hours if necessary) is recommended by Berthelemy[258] and sympathetic denervation by Southworth.[259]

Miscall[260] says: "The decidedly conservative treatment of frost-bite is based on two observations. First, the area that eventually may demarcate as gangrene due to the loss of blood supply is always much less than that originally thought. Second, many cases become infected regardless of early age, especially the hands and feet of those engaged in manual labor.

"Measures to improve the general condition of the patient should be instituted immediately. Adequate heat should be gradually resupplied to the body. Fluids may be administered freely in the form of hot, stimulating drinks or by infusion if necessary. Sedation should control pain. Precautions should be taken to prevent pneumonia, and any cardiac insufficiency should be promptly treated. The immediate local treatment should point to the prevention of infection.

"The temperature of the part may be raised gradually by the body heat of the patient or of another person. This is more efficient than rubbing with snow or other similar procedures and certainly reduces the chances for infection. When the body temperature has been reached it should be maintained continuously at this level.

"The part must be rested and pressure avoided. Elevation aids lymphatic and venous drainage. Any cleansing of the skin should not injure it. Antiseptic solutions are contraindicated. Dry sterile dressing should entirely cover the affected area and be kept in place continuously.

"If the skin is not abraded nor raised by vesicles, active and passive motion may be started early. Moisture of any type should be strictly avoided since it may macerate the skin and thus open an avenue of possible infection. Light massage with baking and physical therapy may later be instituted. These measures are most important for even without necrosis of tissue, the loss of function in extremities may become very great and disabling unless early, adequate treatment is carried out.

"If vesiculation occurs or the skin opens, aseptic dry dressing should still be continued. Large blebs may be opened sterilely and the nails removed if drainage of exudate begins to macerate the tissues This may be done usually without anesthesia The nails will return provided the matrix does not slough. The parts should be kept as dry as possible. Early motion may be encouraged but massage should not be used because of the possibility of infection. Wet dressings should not be used in any form since water logging of the tissue results in gangrene with infection.

"Without infection, a dry gangrene may demarcate in two to six weeks. It is advisable to continue the conservative treatment during this period. The best functional position of the extremity must be preserved by satisfactory measures to prevent very disabling deformities. With gangrene, it is desirable to allow spontaneous separation of the slough which may be much more superficial than the appearance might otherwise indicate. Thus parts may be saved from unnecessary amputation. In addition, such radical treatment usually does not shorten the recovery period

"However, in most cases of severe frost-bite, gangrene with infection usually ensues.

This is particularly true in the hands and feet because of their relatively high contamination with bacteria. The infections are commonly caused by many different types of organisms. *The gas and tetanus bacilli should not be overlooked.*

"With the onset of the combination of moist gangrene and infection, different procedures must be used.

"Wet dressings should be started. A sloughing type of foul infection generally occurs Sodium perborate dressings have been found useful, both to promote separation of the necrotic tissue and to reduce the odor. These may be applied by first covering the part with a thin layer of dry sterile dressings, then sprinkling with the powder and reapplying another layer of sterile dressings. The whole may then be wet with warm, sterile water at regular intervals.

"Any slough including the nails should be aseptically removed. When the infection has partially cleared, hand soaks followed by healing lamps and light vaselin gauze dry dressings should replace the wet dressings. This prevents maceration of the remaining tissues, allows earlier epithelialization and permits motion and exercise to be readily started.

"The part should be kept elevated and in the best possible functional position by the use of splints, braces or other appliances.

"As demarcation occurs it affects the bones as well as the soft parts. The latter may be easily excised. The bone, however, should be allowed to separate spontaneously. In excising

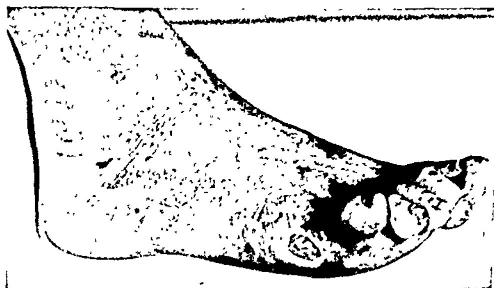


Fig. 111.—Trophic ulcer of the foot following frostbite.

bone, partially devitalized and infected tissue may be incised with possible spreading of the infection and gangrene to even higher levels" Clouston[261] says that no temperature higher than that of the body should be allowed to occur in the location of a frostbite.

Murphy[262] has found passive vascular exercise to be of value in cases of frostbite. Patterson and Anderson[263] describe a mechanical respirator which "seems to improve venous and lymphatic return from the extremities" and say that it may prove of value, especially in the early treatment. Mitchell[264] treats chilblains by the principle of direct elastic pressure. Thin pieces of rubber of the weight of medium rubber gloves are used in strips of tubing $\frac{3}{4}$ to 1 inch wide. These are applied over the affected parts and can be worn on the leg even during walking. In the treatment of the hands, firmly fitting rubber gloves are worn at night only. The condition is relieved instantly. After a few days the part is normal except for slight desquamation. If the skin is broken, boracic powder and a sterile dressing should be applied under the rubber band.

In an experimental study of animals, Fell and Hanselman[265] obtained

much better results in the treatment of frozen extremities if pressure dressings were applied. Sheet wadding and plaster casts prevented death. Elastic bandages were satisfactory. This method of treatment had no effect on saving the extremity, but it was life saving to the dogs. Contrast baths are recommended by Bellander,[266] the warm water being somewhat below body temperature (about 35° C.) and the cold water about 15° C. Herxheimer[267] advises artificial passive hyperemia (Bier's method) for chilblains. A Martin bandage may be used for twenty-two out of twenty-four hours but should not be tight enough to make the limb cold.[268]

Buerger[269] recommends the overnight application of gauze moistened with 70 per cent alcohol. The part is washed with soap and water and alcohol. A sterile dressing is applied and, if necessary, the bullae are punctured. After the sloughs have separated, the infected wound will be treated along the principles previously laid down (Fig. 111). Amputation may in some cases be necessary after the line of demarcation has formed (Fig. 112).

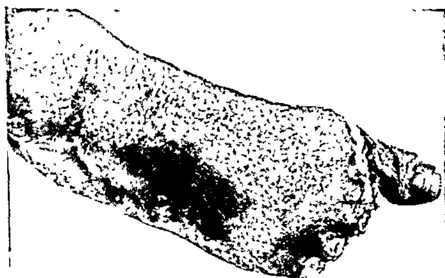


Fig 112.—Gangrene of the great toe and amputation of smaller toes following frostbite.

A case in which tetanus was caused by frostbite was reported by Ioan.[270] Fasal[271] recommends a prophylactic injection of antitetanus serum in cases of frostbite which has been acquired in dirty surroundings. He estimates the incidence of tetanus following frostbite as 3.4 per cent. Bennett and Blount[272] report a case of destruction of the digital epiphyses by freezing, with resulting retarded growth.

TUMORS OF THE BLOOD VESSELS

Stout[273] says that "basically the great majority of vascular growths are benign and only cause trouble because of hemorrhage, disfigurement or damage to a vital organ such as the brain Malignant vascular tumors are very rare and feature especially either the endothelial cell or the pericyte."

He classifies them as follows

Tumors of Blood Vessels

Capillary Hemangioma
- (a) Congenital
- (b) Acquired. "Granuloma pyogenicum"; "hemangioblastoma."
- (c) "Sclerosing hemangioma" (vascular xanthoma)

Cavernous Hemangioma
Venous Hemangioma
  (a) Uncomplicated
  (b) With metaplasia (fat, bone, smooth muscle (vascular leiomyoma), bone marrow).
  (c) Venous racemose aneurysm
Cirsoid Arterial Aneurysm
Diffuse Hemangiomatosis
  (a) Simple
  (b) With congenital arterio-venous aneurysm
Hereditary Hemorrhagic Telangiectasis (Rendu-Osler-Weber's disease)
Capillary Hemangiomatosis of the Retina and Cerebellum (Lindau-von Hippel's Disease)
Generalized Malformations of Vascular Mesenchyme
Hemangiopericytoma
  (a) Glomus Tumor
  (b) Non Specific form
Hemangio-endothelioma*
  (a) Benign
  (b) Malignant

* The neuropathologists sometimes use this term for the vascular form of meningioma.

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CHAPTER VIII

INJURIES OF THE HEAD

WOUNDS

Abrasions of the Scalp.—All abrasions of the scalp must be treated with respect because they are the potential causes of suppuration or cellulitis. The latter are serious because of their tendency to spread, with possible extension to the meninges. It is most desirable to clip the hair and shave the affected area. If the abrasion is slight, however, and in a conspicuous situation, it may be wise to assume the additional risk and leave the hair on. In either case the area should be carefully cleansed with liberal quantities of soap and water. The abrasion may then be treated with 1 per cent gentian violet solution, Aldrich triple dye or sterile white vaselin. A dry dressing is then applied with a head bandage or adhesive tape, which of necessity attaches to the adjacent hair. The dressing and wound should be inspected until a clean dry crust has formed. In case the abrasions become infected, it will be mandatory to clip and shave the scalp in that region and to treat it with hot boric fomentations. When it is impossible to use hot boric fomentations, a less valuable method is to put on a thin coating of white sterile vaselin or mercurochrome ointment before the gauze bandage is applied.

Contusions of the Scalp.—All contusions of the scalp should be regarded as possibly having serious consequences. The patient himself is rarely able to give an accurate opinion as to the amount of force involved in the injury. Contusions of the scalp which appear to be innocent may be the sole indication of more serious injury. Concussion of the brain and fracture of the skull with or without depression may be present. Although undesirable sequelae of head injuries generally occur within the first six hours, all patients with contusion of the scalp should be kept under observation for at least twenty-four hours. A large contusion of the scalp may develop into a hematoma. Superficial extravasations of blood are generally small in amount and do not tend to spread. If the extravasation of blood is below the aponeurosis it may spread over a considerable area of the skull. If the blood is beneath the pericranium, the condition is termed a "cephalematoma." A hematoma may show a soft depressed center which gives a crater-like sensation to palpation and has been mistaken for and operated on as a depressed fracture of the skull.

The *treatment* of contusions of the scalp is the application of cold and bodily rest for the patient. *All of these cases are best considered as potential brain injuries.* It is far better to have the patient spend a number of unnecessary hours in bed than to risk early ambulatory treatment of a brain injury. Most *hematomas of the scalp* absorb spontaneously. Others become fluidified, and persistent fluctuation warrants an attempt at aspiration or incision. Hematomas which have become infected, either before or after evacuation, will have to be drained. The diagnosis of infection of a hematoma is readily made by the presence of pain, redness, swelling and tenderness.

Cephalhematoma or, More Properly, Cephalematoma.—The term cephalematoma is applied to a collection of blood beneath the pericranium. This condition, as Harvey Cushing[1] says, possesses considerable surgical importance, "not only in itself, but because it is often a tell-tale of intracranial stasis." In the infant the effusion generally is limited by the size of the already formed bone. Cushing also has found extradural and subdural extravasations. Even when large the hematoma rarely leaves the confines of a single bone. (Cushing) A cephalematoma is commonly confused with *caput succedaneum.* The latter is a circumscribed area of edema of the scalp which is caused by uneven pressure in the birth canal. The caput succedaneum does not conform in outline to one of the bones; it pits on pressures; it does not fluctuate, and it disappears a few days after birth. A cephalematoma tends to increase in size. The diagnosis is more difficult when the cephalematoma is surmounted by a caput.

Many cephalematomas will subside under expectant treatment. The "let alone" treatment is not without peril, however, as the development of infection is liable to occur in cephalematomas [illegible] cited by Vaughan [illegible] ment. "A full-term, [illegible] labor. After a few days the subsidence of edema of the scalp showed a right parietal cephalematoma. This was treated conservatively and became softer after the fifth or sixth day, but never showed the signs commonly associated with infection. On the ninth day fever and convulsions developed and aspiration of the hematoma showed thin sanguineous pus. Two days later the child died of septic meningitis." Vaughan and Burnham recommended incision and evacuation of the clotted blood on the fourth or fifth day. Cushing's rule is to wait for two weeks and if there is no sign of subsidence, to incise and evacuate the clot. If there were longer delay, the lifted pericranium may give rise to an adventitious bone deposit with a permanent extracranial deformity. After the evacuation of the clots a bandage is carefully applied to cause the separated edges of the cephalematoma to adhere.

Hematoma of the Ear (Boxer's Ear, Cauliflower Ear).—This consists of an extravasation of blood beneath the perichondrium of the ear, causing a rounded fluctuating tumor. This hematoma should promptly be aspirated or incised, the clot evacuated and the incision neatly sutured. A snug bandage over the ear will prevent recurrence. Holden,[3] who advises using sponge rubber to provide the compression necessary in the dressing, says: "Where the cauliflower ear (othematoma) has actually occurred, good cosmetic results can be obtained by incision of the auricle, laying back a flap, after a careful dissection of the perichondrium, and shaving down the cartilaginous areas which produce the deformity. By careful replacement of the flap and suturing, with proper pressure applied, oftentimes a disfigurement can be greatly improved."

Wounds of the scalp are caused most commonly by blows, such as a fall on the pavement or by being struck by a blunt object. Such a blow may cause a jagged, lacerated wound, the edges of which show devitalization and contusion, or it may cause a clean linear wound, like an incision. Incised wounds of the scalp are less common but do occur. Puncture wounds are rare. Because of the extreme vascularity of the scalp, all of its wounds bleed copiously, greatly to the alarm of the patient and those near him. By the time the physician arrives this hemorrhage generally has ceased. If one is present at the time of injury, the best first-aid treatment is the application of a pack of sterile gauze, or in lieu of this a clean towel or handkerchief.

Pressure is then applied firmly on this pack, and bleeding can practically always be controlled unless large vessels, such as the temporal, occipital, posterior auricular and supraorbital arteries, have been severed. Here clamp or ligature will be necessary. The ligature may be applied with a needle. The toothed hemostat is the best for scalp work. (See section on the control of hemorrhage under Open Wounds.)

The first step in the treatment of a scalp wound is the preparation of the field. The skin should be clipped and the scalp shaved (shaving soap and a sharp razor) for an area of at least 1 inch about the wound margins. This should be done as gently as possible in an effort to prevent fresh bleeding. After the area has been shaved and cleansed with clean water, grease, if any,

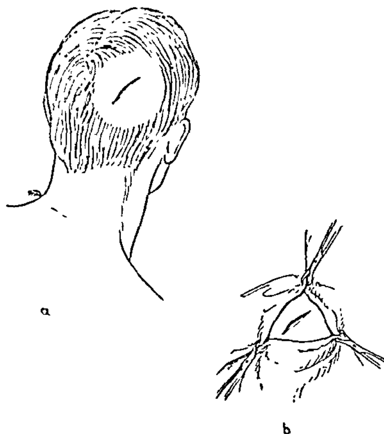


Fig. 113.—Treatment of scalp wound. *a*, Shaving of skin about wound. *b*, Draping area with sterile towels to prevent hair from contaminating the field.

must be removed by benzine or ether. The dry blood should be removed, and after the blood has been washed away from the hair outside of this area the wound is again meticulously cleansed with an abundance of soap and water. Commercial soap flakes in warm water, agitated so as to produce a thick suds or lather, are satisfactory. The water should be sterile and applied from the hose of an elevated irrigating can so as to produce a continuous stream. The hair should be held away from the wound by means of sterile towels held by towel clips (Fig. 113). Whereas fresh bleeding with copious outpouring of blood mechanically washes out many micro-organisms, it is always advisable to cleanse the interior of the wound with soap and water. If very gently performed, this procedure may not stir up fresh bleeding. If, however, fresh bleeding occurs, it will have to be controlled by pressure or

by suture. A great deal of time is lost and a great deal of unnecessary pain is caused by attempts to grasp these bleeders in the scalp with a hemostat and to ligate them. This is rarely necessary, for the bleeding will be controlled by mere pressure or by the sutures which are used to coapt the wound edges. Occasionally hemorrhage from the scalp apparently may be controlled by suture of the skin, but in reality the hemorrhage may be continued underneath the scalp and a hematoma will form. This difficulty may be avoided by proper wound suturing or by the occasionally necessary hemostasis of the depths of the wound. Should a hematoma form, it should be evacuated by devulsing the wound edges or by aspiration under sterile precautions. If the edges of the wound are extremely ragged and devitalized, quicker healing will be insured by débridement of these edges. The ragged ends are removed with sharp scissors or a sharp scalpel. Gross particles of dirt should be removed from the interior of the wound. *Under no circumstances should the physician probe the depths of the wound in search of a possible skull fracture.* The existence of skull fracture is determined far more reliably roentgenographically and by clinical observation than by any amount of probing. A linear slit in the galea may simulate a fracture. Moreover, the probing is dangerous because of the likelihood of the introduction of infection.

Many more scalp wounds are sutured than really require this treatment. Inexperienced physicians who are alarmed at preliminary hemorrhage will place sutures before they have made a serious attempt to control the hemorrhage by the application of pressure and before the defense of clotting has fully been exercised. Wounds up to 1½ inches in length will heal very kindly without being sutured and generally with much less danger of sealing pyogenic organisms in the wound. The surgeon may best expend his efforts in industrious cleansing and antisepsis and the application of a comfortable and well fitting bandage, not in the introduction of sutures in a small wound.

In the event that closure of the wound is decided upon, adhesive plaster bridges are suitable for small wounds if the surrounding skin has been sufficiently shaved to permit their application. Michel clips are less suitable; the best method is the insertion of fine, nonabsorbable suture material. For this purpose silk, "dermal suture" and horsehair are preferable. Silkworm gut is too stiff and too thick to be suitable, and catgut never should be employed. Strong cutting needles should be used. Sutures in the scalp may be introduced without anesthesia in all but the most apprehensive and in young children. If anesthesia is thought to be necessary, local anesthesia in the wound edges is more troublesome to employ but is most suitable. General anesthesia may be needed for large wounds and in young children. Wounds are sutured without drainage. A sutured scalp wound should be inspected at least every twenty-four hours for the first five days for signs of infection. This is manifested by pain about the wound, redness, slight swelling and occasionally the appearance of a droplet of pus at the stitch wounds or at the wound itself. At the first sign of infection all the stitches should be removed. If the infection is slight, simple removal of the sutures will suffice. If, however, there is a more marked disturbance, the employment of moist boric dressings will be indicated.

[illegible] of the Scalp.—This serious accident occurs in accidents where the [illegible] the scalp torn off. If the portion of th[illegible] [illegible]road pedicle [illegible] may be cleansed and [illegible]

sutures at the borders and appropriate counterdrainage at the base of the flaps with reasonable assurance of a successful result. Where the entire flap has been removed and a large area of bare periosteum or skull exposed, the best treatment is probably that which was used in the days when scalping by the Indians was a relatively common occurrence. In 1777 a Dr. Vance advocated the method of Augustin Belloste,[4] which consisted of trephining through the outer table of the skull numerous small holes. Vance bored multiple openings in the outer table of the skull to the diploe with a shoemaker's awl and ceased boring "when a reddish fluid appeared at the point of the awl." "Proud flesh" appeared to rise in these holes, but Vance observed that "it skins over remarkably slow."[5] Through these small holes, abundant granulation tissue forms and coalesces, so that the entire area eventually becomes covered with a clean granulating surface on which Thiersch grafts should be placed. Eisenstodt[6] reports a case in which the avulsed scalp was shaved and cleansed and then sutured in place. The skin eventually sloughed off, leaving a bed of granulation tissue which was covered by dermatome grafts. Two similar cases with excellent results are reported by Kelly.[7]

Burns of the scalp are of far less frequent occurrence than burns of the face and neck because of the protection exercised by the hair. The practice of permanent waving has been the cause of numerous burns of the scalp. These "*permanent wave burns*" are generally endured by the victim on receiving assurance that everybody else has suffered in the same manner. They should be treated with great care as to antisepsis because most frequently they become infected. The writer has seen a case of marked cellulitis of the scalp and face resulting from a permanent-wave burn which was so serious as to cause the closing of both eyes. This patient required hospitalization and treatment with moist compresses. There was ultimately complete loss of hair in an area about 1½ inches in diameter. Extensive burns of the scalp are best treated by clipping the hair and application of a petrolatum pressure dressing using elastic woven bandages.

Abrasions of the Face.—Small abrasions of the face are best treated by careful cleansing of the wound and surrounding skin with abundant quantities of soap and water. The wound is then encouraged to dry. If secretion forms, this is removed by gently sponging with applicators saturated with boric solution or with small pledgets of gauze. The wound itself is left freely exposed to the air and is sponged whenever the secretion becomes too profuse. It is usually wise to sponge the wound with boric acid solution every fifteen minutes for three or four hours and at less frequent intervals thereafter. In a short time the secretion will dry, and a clean scab will form. This is not covered by any protective dressing and, when the epithelium beneath it heals, will fall off without further treatment. The patient, of course, is cautioned not to touch the dry wound or the subsequent scab with his fingers because of the risk of infection. Painting the abrasion with 1 per cent gentian violet solution or with Aldrich dye (see Index) is satisfactory but unsightly. If there is marked likelihood of contamination with dust or if the appearance is a factor, a sterile dressing is applied, the abrasion first being coated with sterile white vaselin or sterile borated vaselin. The dressing is usually held in place with adhesive plaster. Under no circumstances should collodion or "new skin" be painted upon the abrasion. The writer has known of a case of tetanus arising from an abrasion of the face incurred by a fall on the street and treated with collodion.

Following blast injuries, dirt, powder grains, coal dust, and, under other circumstances, portions of emery from emery wheels may be driven into the skin. A fall in a cinder driveway or on gravel has been known to grind into

the skin small particles of cinders or stones. These particles are exceedingly difficult to remove, but a very earnest effort should be made to do so as soon after the accident as possible. For this purpose it will usually be necessary to give a general anesthetic and to scrub the abraded skin with gauze pledgets or actually to scrape it with a stiff sterile brush and green soap. If these procedures are not taken, often a very disfiguring permanent tattoo-like discoloration of the skin will occur (Fig. 9).

Contusions of the Face.—Practically all portions of the face swell very readily following blows. Contusions of the face are manifested by rapid swelling and pain. Some areas, such as the lip, are particularly prone to become swollen. A second characteristic of contusions of the face is the likelihood of ecchymosis. Such ecchymosis is particularly liable to occur in the neighborhood of the orbit. It will be remembered in the consideration of ecchymoses of the face or any other portion of the body that the ecchymosis often occurs at a site that is more dependent than that of the injury. A blow of the scalp or brow will cause ecchymosis of the upper lid and even of the lower lid. Ecchymosis in the region of the orbit never should be lightly dismissed on the grounds that it may be caused by simple contusion of the soft parts. It should be observed and suspected of being related to injury to the underlying osseous system. If the ecchymosis involves both orbits on the nasal side and if it appears some forty-eight to seventy-two hours after the injury, the evidence strongly indicates a fracture involving the orbital plates or the base of the skull. Likewise, a bilateral subconjunctival hemorrhage must be considered a suspicious sign of skull fracture. Unilateral subconjunctival ecchymosis or hemorrhage which occurs almost immediately after the injury will generally be explained by contusion of the conjunctiva itself. Likewise, ecchymoses of the orbit which occur soon after the injury may be attributed to injury to the soft parts of the orbit itself. All such subcutaneous hemorrhages in this region which cannot be explained upon simple grounds should be observed on the basis of a possible skull fracture. The treatment of the local condition of contusion of the face is the application of cool or cold moist compresses. Extensive ecchymoses on the forehead may develop into fluidified hematomas which may require aspiration. Later, hot fomentations will facilitate absorption. Contusions in the region of the supraorbital nerve are extremely painful and may cause temporary anesthesia of the portion of the scalp supplied by that nerve.

Incised and Lacerated Wounds of the Face.—The face is frequently the site of incised wounds, particularly nowadays because of shattered glass from windshields in automobile accidents. The chief concern in the treatment of these wounds is the promotion of healing with a minimum amount of scar formation. To this end, after careful cleansing with an abundance of soap and water, and excision of ragged devitalized borders, the edges are approximated with very fine nonabsorbable suture material which is placed by a very fine curved cutting needle. Very fine nonabsorbable sutures on fused needles are now available commercially ("dermalon"). The sutures are introduced about ¼ inch apart and are carefully tied so that there is no inversion of the skin edges. The best suture materials for wounds of the face are horsehair, fine twisted silk or the so-called "dermal suture." The earlier the sutures are removed, the less will be the scar formation; generally the second or third day is the best time. Adhesive plaster bridges are often

satisfactory. After the sutures have been removed several applications of collodion at five to seven day intervals may minimize the width of the scar.

Webster,[8] in speaking of facial lacerations, says: "Certain of these, where there has been oblique slicing, we feel require adequate pressure made on the dressings to prevent collection of blood, which may result in thickened scar tissue and possibly rolled-up skin flaps; the latter, however, do not occur if thorough irrigation with saline solution, closing the tissues in layers and removal of devitalized tissue are done. A pressure dressing on this may make all the difference in the final outcome and may make secondary operation unnecessary. There are times when I will apply xeroform gauze dressing and other times when saline compresses are necessary if bruised tissue cannot be excised without distortion."

In the case of children a general anesthesia is frequently necessary. Most adults, however, will readily tolerate the placing of a few sutures without anesthesia, but in the more apprehensive individuals the injection of the wound margins with 1 or 0.5 per cent novocain solution will render the insertion of the stitches completely painless. This procedure takes little time and is greatly appreciated by the patient. Small ampules, 1 to 2 cc. in size, containing local anesthetic solution are on the market. A small hypodermic syringe with a fine gauge needle having a short bevel should be used for injection. Instillation of butyn solution into the wound is also helpful.

In case of *wounds of the lower lip and chin*, particularly in children, the placing of gauze dressings has actually a detrimental influence. It is impossible to keep these dressings clean and dry, and they soon become saturated with saliva and fluid food; upon their removal the wound will be found to be macerated and infected.

Webster[8] says: "*Certain lacerations about the mouth are better without any dressings*, and I have the nurses keep the secretions from collecting about the skin edges and sutures by the use of tooth-pick swabs and occasionally 50 per cent hydrogen peroxide but more usually saline solution. I frankly see no appreciable antiseptic effect in boric acid solution but do find that crystallization occurs with this where it will not with normal saline. I do use with saline packs a fine-meshed gauze next to the wound, and this is changed every two to four hours with the change of dressing."

If sutured wounds of the face show redness, swelling and discharge at the wound margins, infection may be suspected. This may be superficial and amenable to repeated sponging with boric solution, but if the pain and amount of disturbance indicate deep infection the sutures should be removed and warm boric dressings applied. Accurate approximation of the wound edges is important in all wounds of the face. It is important that the bite of the needle on each side of the wound be equally placed from the edge of the wound and it is important that the skin edges be not invaginated, as otherwise a more conspicuous scar will result.

Wounds which sever the ear require accurate approximation with interrupted sutures. It is surprising how beautifully these wounds will heal even though more than half the ear is severed from its pedicle. It may be necessary to apply a bandage to the sutured ear. In this case a loose gauze fluff should be placed behind the lobe of the ear before the circular head bandage is applied.

Incised and lacerated wounds of the face are frequently of importance because of the structures involved in the wound beneath the skin. Wounds of the brow have been known to sever the supraorbital nerve and to cause anesthesia of the affected scalp until regeneration of the nerve takes place.

This generally occurs without suture. The facial nerve may be cut in a wound of the side of the face, with resultant facial paralysis. These injuries will require nerve suture frequently. Stensen's duct may be cut in a wound of the cheek, and a very distressing condition is created in which the saliva drains out on the cheek. According to Dickinson,[9] primary repair of the duct always should be attempted as in some instances it is followed by very gratifying results. Secondary repair is much more difficult, and its results are not always so satisfactory. Probably the most satisfactory and easiest method of dealing with a fistula of this portion of the duct consists in converting the external fistula into an internal one. A wound into the substance of the parotid gland will cause a parotid fistula, which generally, however, heals spontaneously.

Wounds of the cheek and of the lips may be of such depth as to involve the mucous membrane and penetrate into the mouth. If the wound is more than ½ inch in length, it is generally desirable to suture it. In this case the sutures are neatly applied to the skin side of the wound, so that the bites of the needle penetrate through from one fourth to one half of the thickness of the cheek. The open wound on the mucous membrane side of the cheek is usually not sutured. A very common accident is for persons, particularly children, to fall in such a manner that a tooth is driven through the lip. Most frequently the wound merely penetrates part way through the lip from the mucous membrane side. Such a wound requires no treatment other than a mildly alkaline antiseptic mouth wash five or six times daily. Occasionally the tooth may penetrate the entire lip and cause a wound on the external surface. Unless this wound is very large, no treatment will be required other than that employed in partial penetration. Large wounds of this type should be sutured on the skin side only.

Wounds of the eyelids require special care, and general anesthesia is usually advisable. Schaub[10] says:

"In *complete lacerations* of the lids, a number of very important points must be kept in mind: (1) When the work is completed there must be perfect approximation of the lid to the globe. *This necessitates perfect approximation of the cut lid margins.* (2) Deep sutures, preferably of No. 0000 plain catgut, should be used to approximate the deeper portion of the wound. These sutures should *grasp the conjunctiva from the lid side,* but the suture should not be made to present itself on the conjunctival side of the lid. Simply, it is a subconjunctival stitch taken in the depths of the wound, catching the conjunctiva in the fashion in which a subcuticular stitch is used in the skin. (3) Skin sutures should be *fine*—horsehair or fine silk—without undue tension placed upon them. (4) Frequently a dimpling occurs at the site of a through-and-through laceration. Excision of a small elliptical piece on each side of the wound will prevent this. (5) A firm compression dressing should be used for a few hours at least, and then, most surgeons agree, it is wise to treat the repaired area as an open wound. Too often, eye patches are placed and not removed for twenty-four hours at a time. Such procedure promotes infection, secretion bathing the sutures, usually with a tearing out of them.

"It is our practice to cleanse the wound with salt solution, two to four times daily, [illegible]

Animal bites of the face are particularly liable to i [illegible] d their roughened edges will adapt th[illegible] to accurate ap[illegible]. Bites

of dogs which are suspected of being rabid present a difficult problem. Ordinarily such wounds should be thoroughly cauterized with fuming nitric acid, but the marked increase in the amount of scar formation which this procedure brings about makes its omission desirable. It is better in this case to cleanse the wound thoroughly, with soap and water, suture loosely if necessary, observe the dog, and if indicated administer the antirabic treatment. (See section on Rabies.)

Puncture wounds of the face result from falls on nails or pitchforks or are made by awls, ice-picks, etc. Outside of the chief danger, that of involving the eye, they merit consideration because of the likelihood of tetanus infection and of penetration of the sinuses.[12]

Wounds of the Tongue and Soft Palate.—Not uncommonly children will fall upon a sharp object with the mouth open, and a wound of the soft palate will occur. These wounds will require careful approximation with interrupted silk sutures placed by means of a small curved cutting needle under general anesthesia.

Wounds of the tongue most commonly result from falls on the chin when the tongue is between the teeth. Such wounds may be very severe. Small wounds of the tongue are best treated without suture. Wounds 1 to 1.5 cm. in length with wide open, gaping edges will heal rapidly and cleanly with no other treatment than the periodic use of a mild antiseptic mouth wash. If the tongue is badly lacerated, so that a portion of it hangs to one side, the introduction of interrupted silk sutures is indicated.

Burns on the face result from many causes. Hot water, steam, gasoline explosions, explosions of gas stoves and the like have caused burns on the face. Mild first degree burns of the face which cause a simple erythema require no other treatment than the application of a soothing ointment, such as cold cream, or even talcum powder. All other burns of the face are best treated by soap and water cleansing, the application of sterile petrolatum and a pressure dressing held in place by a woven ("Ace") bandage. (See section on Burns.)

Ocular Injuries.—The eyeball itself is subjected to all varieties of wounds. If the conjunctiva alone is merely scratched, the instillation of a 1 or 2 per cent aqueous solution of mercurochrome or of a 5 per cent argyrol solution two or three times daily will suffice for treatment. Zinc sulfate, 1 grain to the ounce, is useful. If there is a scratch or an *abrasion of the cornea*, this condition will require the services of an ophthalmologist. The infection which may result from such trivial scratches of the cornea may bring about its ulceration.

Jones[13] say [illegible]
to the cornea [illegible]
first aid pro[illegible]
economic sta[illegible]
infected and treated accordingly. Just as soon after an injury to the cornea as is possible (the sooner the better), a few drops of butyn or cocaine, the former being preferable, are instilled. Immerse the blade of a corneal spud in the alcohol bottle, instill more anesthetic in the eye; ten minutes from beginning, take the spud and gently lift away the foreign body, being careful to injure as little of the corneal substance as possible. Wrap a few shreds of cotton around a toothpick; dip in mercurochrome or iodine and touch the abraded surface. If the abraded surface is as much as a square millimeter, instill a drop of 1 per cent atropine, or some atropine eye salve, except in persons over fifty years of age. And unless the patient can stay indoors, put on a dressing and let it remain for twelve hours. Then if there is any pain or discoloration about the site, the case should be treated as an ulcer of the cornea."

Contusions are treated by cold compresses for ten minutes every two hours (Rutherford). Burns are treated by instilling castor oil or sweet oil and 1 per cent homatropine drops. A wound which causes penetration of the anterior chamber should be given first-aid treatment consisting of the instillation of a mild antiseptic, and the patient should be immediately referred to an ophthalmologist. A small *puncture wound of the cornea*, which permits the escape of the aqueous humor of the anterior chamber, is not necessarily very serious, and good recovery generally follows. Wounds of the conjunctiva may be sutured with fine catgut after preliminary irrigation with a mild antiseptic and débridement if the edges are ragged. Wounds of the eyelid are closed with very fine interrupted horsehair or catgut sutures. Young[14] reports a case of bee sting of the cornea and states that bee stings are probably never absorbed by the tissue.

HEMORRHAGE FROM THE HEAD

Hemorrhage from the scalp is always very profuse and often very alarming to those not acquainted with the nature of the vascular supply of this region. The hemorrhage generally is readily controlled by direct pressure or by sutures which approximate the edges of the wound. The exceptions to this are in cases in which a large vessel, such as the temporal artery, has been severed. In this event grasping the severed vessel with a hemostat and ligation will be necessary. In case this is not feasible the hemorrhage can be controlled by passing a deep suture beneath the bleeding point and ligating the tissues *en masse* in that locality. Severe hemorrhage from the scalp from multiple wounds may be controlled by tightly applying a circular tourniquet about the base of the skull and over the brow. If this tourniquet is constricted tightly enough it will obstruct the arterial circulation, and the hemorrhage will cease. This measure, however, rarely is necessary. (See section on Scalp Wounds.)

Hemorrhage from the Face.—Hemorrhage from wounds of the forehead rarely is alarming. On the cheeks, however, where the vascular supply is more profuse, serious hemorrhage may take place. Large branches of the facial artery may be severed and will require prompt ligature. The measures of direct pressure which are applicable upon the scalp are scarcely feasible upon the face because of the irregularity of the underlying bony structure and because of the mouth. If a hemostat is not available, deeply passed sutures often will control the hemorrhage.

Hemorrhage from the Nose (Epistaxis).—The causes of epistaxis are numerous. Most commonly, the bleeding is caused by blows upon the nose and by fractures of the base of the skull. Removal of dried secretions in the anterior nares, ulceration of the septum, vicarious menstruation, tuberculosis, lues, malignant disease, nasal polyps, angiomas, diphtheria, scarlet fever, purpura, scurvy, leukemia, high arterial blood pressure and renal and hepatic diseases all have been mentioned. In cases of bronchitis, emphysema and cerebral congestion there may be sufficiently high venous blood pressure to bring about epistaxis. Alterations in atmospheric pressure, such as are brought about by high altitude, diving or caisson disease, have been known to cause epistaxis. An additional cause is hemophilia. Various treatments have been recommended for use in epistaxis, in accordance with the cause and the severity of the condition. The upright position of the patient lowers the blood

pressure at the site of the hemorrhage and favors clotting. The time-honored remedy of placing ice on the back of the neck is probably chiefly of value in that it makes the patient hold very quiet to keep the ice in position. It is of great importance to have the patient breathe through the mouth and not blow the nose in an effort to expel the clotted blood. Harmon Smith[15] says that adrenalin solution (1:1000) or hydrogen peroxide applications will stop mild hemorrhages. He also recommends fused silver nitrate, tannic and gallic acids and compound alum powder. Monsel's solution (liquor ferri subsulfatis) has been recommended. Occasionally rhinologists will be able to cauterize the bleeding point in the anterior nares. Hertzler and Chesky[16] recommend the cocainization of the ulcer and its cauterization with trichloracetic acid. Reforming of the ulcer may be retarded or prevented by applying yellow oxide of mercury to the area. Hemorrhage which does not respond to these measures will require packing of the nose. The anterior nares may be packed by carefully and firmly inserting ½ inch selvedged gauze packing under a moderate amount of pressure (Fig. 114). A very useful appliance is the Simpson nasal tampon. This consists of a wedge-shaped

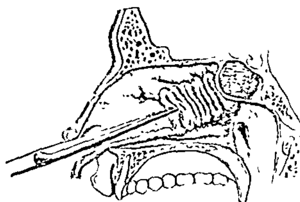


Fig. 114.—Packing of the anterior nares. (Maisonnet, J: Petite Chirurgie, Paris, Gaston Doin et Cie, 1928.)

piece of some material which expands when subjected to moisture. It comes in various sizes. The blood in the nose will cause these tampons to swell up and tightly occlude the anterior nares. In some cases the bleeding point will be so far posterior that it will be impossible to control it by these measures, and it will be necessary to pack the posterior nares. This is accomplished by passing a soft rubber catheter into the nostril and down into the pharynx, where it may be grasped and brought out through the mouth. Through the oral end of this catheter is then tied a strong silk ligature. To the other end of this ligature at a distance of some 12 inches is tied a pledget of gauze (Fig. 115). On this, in turn, is tied an additional 12 inches of silk ligature. The catheter and first silk ligature are then withdrawn from the nostril until the pledget is firmly pulled upward into the posterior nares. The pledget of gauze may be held tightly in position by tying the silk ligatures over another gauze pledget at the anterior nares (Hertzler) (Fig. 116). The distal ligature, which then protrudes from the mouth, is fastened for convenience to the proximal ligature which protrudes from the nose. Shambaugh[17] ties the two strings across the front of the nose over a piece of gauze and uses a third string hanging out of the mouth to withdraw the pack. The nasal pas-

sages are also packed. He says: "A postnasal pack should be removed *within twenty-four hours* because of the danger of otitis media, but if iodoform gauze is used, this complication may usually be avoided. A nasal pack should be removed in twenty-four to forty hours, but if profuse epistaxis recurs,

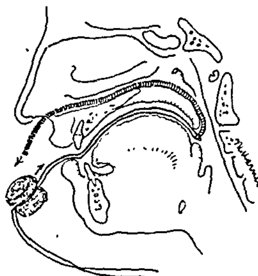


Fig. 115.—Packing of the posterior nares. A soft rubber catheter is introduced into the nostril until it appears in the pharynx. It is grasped with an instrument and drawn out through the mouth. A strong silk ligature is then attached to the tip of the catheter. A pledget of gauze is attached to the other end of the ligature at a distance of about 1 foot from the tip of the catheter. The catheter and ligature are then withdrawn from the nostril.

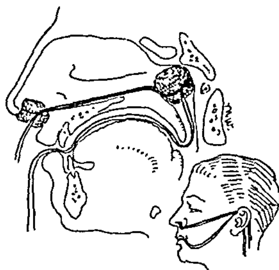


Fig. 116.—The silk ligature is drawn out of the nostril, and traction is put upon it so that the gauze pack is forcibly applied to the bleeding area in the posterior nares. The [illegible] A second [illegible]
The ligature ends may be hung over the ear for convenience.

both packs must be reinserted and may have to be left in for as long as four days."

According to Moorhead,[18] the best plan is to insert far into the nostril the finger of a rubber glove or a finger cot and to inflate it with air or water.

Ferguson[19] advises the application of intranasal pressure "by inserting a finger cot or the finger of a rubber glove into the nostril. The end of the finger cot is held open and the cot tightly packed with dry gauze or ribbon packing. The gauze is then moistened; this causes it to swell and produce firm and continuous pressure at the bleeding site. The pack may be left in place twelve to eighteen hours." (Fig. 117.) Denny[20] advised the following plan: "By means of a soft rubber catheter a condom is passed through the anterior nares into the posterior nares; the catheter is withdrawn, the condom is inflated and tightly tied just outside the anterior nares. Further directions are unnecessary. Advantages: no pressure pain, ease of removal, ease of carrying out technique."

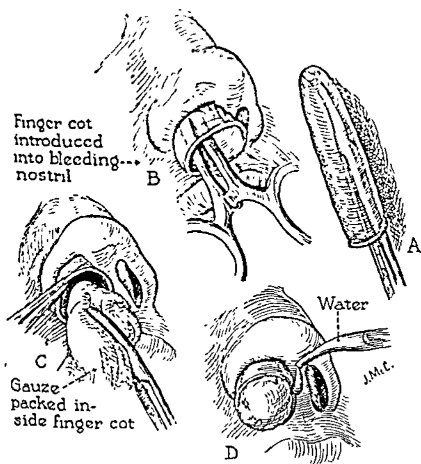


Fig. 117.—Method of using a finger cot for the control of bleeding from the nose. (Ferguson, L. K.: Surgery of the Ambulatory Patient, J. B. Lippincott Co.)

Houser[21] finds that ½ inch *oxidized cellulose gauze packing** gives results that are "vastly superior" to those obtained with regular gauze packing in the treatment of nasal bleeding. Another method which seems rather homely, but which is apparently very effective, is the use of salt pork.[22] Pieces of salt pork are kept in saturated solution of sodium chloride until their use is indicated in cases of severe nasal hemorrhage. A piece of salt pork of appropriate size is inserted into the anterior nares so as to cover the bleeding point. Dack[23] reports the successful treatment of epistaxis with injections of moccasin snake venom. Leggo[24] says that 90 per cent of the bleeding points can

* ½ inch Hemo-Pac, supplied by Johnson & Johnson.

be compressed by pinching the nostrils together with the thumb and forefinger. The compression is exerted by the patient himself, who holds the position for a half hour, if necessary, and is cautioned against blowing his nose or violent cleansing afterward.

Hemorrhage from the Ears (Otorrhagia).—Hemorrhage from the ear is caused by fractures of the base of the skull, injuries to the external auditory meatus and rupture of the tympanic membrane. It is also found in acute hemorrhagic otitis, granulations of the external auditory meatus and malignant disease. In all cases in which traumatism is suspected as being the cause, it is of extreme importance to determine if possible if the blood in the external meatus has run in from the outside. It is often found that a scalp wound in the temporal region will cause considerable blood to run into the ear, and if the ear is carefully cleansed, it will be found that the blood is merely in the outer part of the meatus and that the region of the tympanum is free from it. If blood is demonstrated as arising from the tympanum in cases of traumatism of the head, it is a safe working rule to

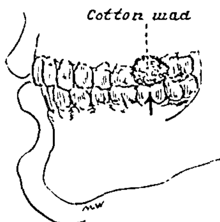


Fig. 118.—Control of hemorrhage after tooth extraction. An oversized cotton wad is firmly packed into the tooth socket, and tight pressure by the lower jaw retards the bleeding.

make a diagnosis of fracture of the base of the skull. Hemorrhage from the ear rarely is profuse enough to be troublesome. In those cases which are due to fractures of the skull, the best treatment is that directed to the underlying condition. (See section on Head Injuries.) The external auditory meatus is carefully cleansed with a sterile cotton applicator which has been moistened with boric solution. The auditory meatus is loosely plugged with sterile cotton. In cases in which there is injury to the external auditory meatus alone, if the bleeding does not quickly subside spontaneously, a light pack of narrow-selvedged gauze may be put in place.

Postoperative Tonsillar Hemorrhage.—Tonsillar hemorrhage may occur primarily from inadequate ligation of bleeding vessels in the tonsillar fossa or secondarily from the avulsion of clots from the raw surface, which is brought about by the violent gagging efforts of the patient. A profuse hemorrhage may be instituted in this manner. It is particularly important to observe patients suspected of having tonsillar hemorrhage to see if they may be swallowing blood and giving a false impression of security because no blood is expectorated. The first warning in some of these cases is a copious emesis

of swallowed blood. The treatment of tonsillar hemorrhage varies with its severity. The milder hemorrhages are controlled by the application of an ice collar and rest, which is aided by a hypodermic injection of morphine. The application of astringents, such as Monsel's solution, ferric chloride, compound alum powder, or coagulants, such as thrombin, frequently is of value when there are large areas of oozing raw surface. Direct pressure with a pledget of gauze on the end of the forceps or by means of a Mikulicz-Stoerk tonsil hemostat may be necessary. Where all such measures fail, the patient should be taken to the operating room, and with the aid of good light and occasionally general anesthesia the bleeding points should be grasped with a hemostat and ligated. Occasionally ligation of the external carotid artery will be necessary.

Hemorrhage from a tooth socket may be controlled by packing the socket with an excess of cotton or gauze and then by tightly closing the jaws, causing firm pressure upon the pack (Fig. 118). The pack may be saturated with a coagulant, such as "thromboplastin."

Hemorrhage After the Use of Cautery.—Severe secondary hemorrhage may occur after the use of surgical diathermy or the actual cautery in the treatment of neoplasms of the face. The separation of the eschar, which may occur some days after the operation, may be accompanied by very profuse hemorrhage. Such hemorrhages must be treated as any other hemorrhage from wounds of the face, by pressure if possible and ligatures if necessary.

FRACTURES AND DISLOCATIONS INVOLVING THE HEAD

Fractures of the Nose.—The most common fracture of the face is the broken nose. Fractures of the nasal bones are of far more serious significance than the mere facial disfigurement indicates. The nasal bones are attached to the perpendicular plate of the ethmoid, the vomer, the cartilaginous septum, the superior maxilla and the frontal bone. Most of these fractures are compound, *either the skin or the mucous membrane being injured. Resulting infections* may be the cause of abscesses, osteomyelitis or liquefaction of cartilage. Displacement of the nasal bone or of the septum may bring about serious impairment of the nasal air passages. The diagnosis is generally made on the basis of swelling, tenderness and crepitus. The last sign is best elicited by the most gentle palpation. Roentgen examinations of the nose are of diagnostic value in the adult. The diagnosis may be difficult in children. Kazanjian[25] says: "(1) Any blow to the nose causing epistaxis requires an x-ray examination, as in simple fractures there is often enough soft tissue reaction to conceal the depression of the nasal bone and confuse the diagnosis. (2) The fracture should be reduced as soon as possible after injury, especially in children as their bones heal very readily, and a postponement of a week may be too late. (3) Fractures involving the cartilaginous part of the septum should be corrected within 24 hours. (4) Lacerations of the nasal mucous membrane should be carefully sutured to their original position and supported with frequent loose packings. (5) Fractures involving both nasal bones and also comminuted fractures should be supported by adequate splints following surgical manipulation." The aim of treatment is the restoration of the parts to their normal anatomic positions. This means restoration of the nasal passages to insure good breathing space and also restoration of the outer conformity of the nose. In most cases the former of these two

requirements will be the more important. The anterior nares should be carefully cleansed of adherent blood clots and washed out with a mild antiseptic solution, such as boric acid or dilute mercurochrome. If a wound is present on the outside of the nose, this likewise should be cleansed and treated with a mild antiseptic. It is then generally advisable to anesthetize the patient and to insert in the nostril a small curved artery forceps, periosteal elevator or urethral sound, and by manipulation of this, together with palpation of the outer parts of the nose, to make an effort to restore the broken fragments to their normal positions (Fig. 119).

Where there is a tendency for the deformity to recur, an external splint with forehead attachment or internal packing or an Asch tube should be employed. Salinger[26] attaches his splint to a plaster headcast. The nasal cavity should be cleansed three times daily with an antiseptic wash. Anatomic reposition is particularly important in children where the deformity may be accentuated with growth.[27]

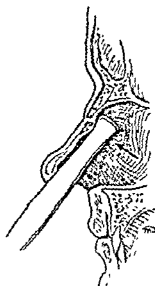


Fig. 119.—Elevation of a depressed fracture of the nose.

Blows upon the face may *fracture the orbital plate* or the malar process in such a manner as to permit passage of air from the frontal sinus to the orbital tissues (orbital pneumatocele). The writer recalls a case of a young man who, shortly after a boxing match in which he was struck on the face, blew his nose and to his astonishment created a large area of orbital subcutaneous emphysema. A second effort to blow the nose merely increased the size of this emphysema. The air which is so injected under the skin will readily absorb without active treatment.

Fractures of the orbital arch of the frontal bone may involve injury to the lacrimal gland or to the eye (Fig. 120).

Fractures of the malar bone are caused by blows upon the side of the face. There is generally a depression on the side of the face and below the eye. The displaced fragment may interfere with the movement of the coronoid process of the inferior maxilla and thus cause limitation of the movements of the jaw. The mesial displacement of the malar bone will cause narrowing of the orbit, with the result that the eye is slightly protruded and diplopia results. (See Fig. 121 for the roentgenographic appearance in such a case.)

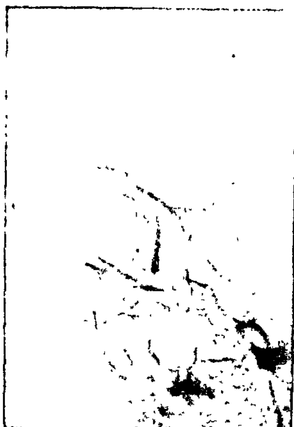


Fig. 120.—Fracture of the supraorbital arch of the frontal bone.



Fig. 121.—Fracture of the malar bone. The orbit was narrowed in this case, and diplopia and some exophthalmos were present. No attempt at reduction was made, and the diplopia disappeared after several weeks.

Scudder[28] has given the following directions for making an examination for fractures of the malar bone:

"Palpation of the malar bone is somewhat difficult. The best method of doing it is to stand behind the sitting patient and to feel both malar bones at the same time—the left

one with the left hand and the right one with the right hand. The malar process of the superior maxilla is felt inferiorly by pushing the skin of the cheek upward. The orbital part of this process is felt superiorly at the middle of the inferior border of the orbit Following the orbital margin outward and upward, the orbital border is palpated up to the frontal process. Following the malar process of the superior maxilla backward, the free inferior border of the malar is felt continuous backward with the zygomatic process. Starting on the frontal process, the posterior border of the malar may be palpated downward and backward to the upper border of the zygomatic process of the temporal bone. The inferior surface of the malar may be felt by placing the fingers, palm upward, in the superior sulcus of the cheek and following backward until the coronoid process of the lower jaw is felt. In the case of a fracture that is as often unrecognized as is this one, it is important to be very familiar with the details of the outline of the bone."

The lesser displacements of the malar bone will not require treatment. Even when diplopia is present, the eye muscles will compensate for the changed requirements, and single vision will be restored after three or four weeks. Interference with the coronoid process will require treatment. Before cutting operations are resorted to an attempt should be made with a blunt instrument to raise the fragment from inside the mouth. Ivy and Curtis[29] advise elevating the depressed fragment of bone to its normal position as soon after the injury as possible. The method of elevating the depressed fragment of malar bone preferred by them is that described by Roberts.[30] This method is as follows: A very small horizontal incision is made ½ inch *vertically below the outer canthus of the eye through the skin* and is carried down to the bone. A special corkscrew-like instrument is passed through the middle of the depressed bone, and by this means a firm hold is obtained whereby the fragment can be manipulated into place. It will usually remain in position without a tendency to recurrence of the depression. The screw is withdrawn, and the skin incision is closed with one fine suture. Codman grasps the fragment by means of a blunt double hook through the skin. When these methods fail, a small incision should be made and the fragment raised by means of a hook or screw elevator. Great care should be exercised so as not to inadvertently force the fragment into the orbit and injure the eye. Straith[31] treats a depressed malar bone by "passing an antrum trocar *or a heavy curved instrument through the mucous membrane behind* the last upper molar up and beneath the malar bone behind the maxilla. Upward pressure against the depressed portion usually suffices to elevate it satisfactorily." (Fig. 122.) It is often surprising how inconspicuous a small depression on the side of the face will be, and open treatment should be undertaken only after serious consideration.

Fractures involving sinuses are potentially the cause of infection which may proceed from the sinus itself to the adjacent soft parts. The rationale of the treatment is the reduction of the fractures and the protection of the sinuses, which is carried out by a rhinologist.[32] Shea[33] says: "The management of fractures involving the paranasal sinuses follows the general principles of *sinus surgery. The end results should be a restoration of the features,* especially to obtaining symmetrical orbits, a reestablishing of good ventilation and drainage of the sinuses, and a satisfactory bite."

Blows upon the zygomatic process may cause depression of this bone, and it will be necessary to elevate the depressed fragment by means of a small *hook inserted in a small wound made under local anesthesia.* In cases of depressed fracture of the zygomatic arch the method of Matas,[34] quoted by

Ivy and Curtis, is of value. A heavy curved needle is passed through the skin from above downward beneath the depressed fragment to emerge below the arch. This needle is threaded with heavy silk, which, in turn, serves as a carrier for a piece of silver wire. The two ends of the wire are twisted together and afford a means of traction on the bone fragment whereby it is elevated into position. In case of tendency to recurrence, the wire is twisted over an ordinary glass microscope slide whose ends rest on the firm portion of the bone.[35] (See Fig. 123.)



Fig. 122.—Straith's method of elevating depressed malar by means of antrum trocar or other strong curved instrument. This method is simple and efficient in most cases. (Straith, C. L.: *J. A. M. A. 108: 101, 1937.*)

The method of Sir Harold Gillies is described by Greeley:[36] "Preferably under general anesthesia, a small curved incision is made under aseptic technique through a shaved area in the temporal region. This should be made within the hair line, where the resulting scar will not be visible. The incision is carried down to the temporal fascia. The wound edges are then retracted while another small incision is made through the temporal fascia, thus exposing the temporal muscle. Through this opening a long thin elevator is passed downwards superficial to the temporal muscle until it comes to lie deep to the depressed zygomatic-malar bones. Those who have never performed this operation will be greatly surprised to find that the elevator practically falls down through this plane by its own weight. Certainly, no force is necessary to place it and furthermore it is practically impossible for the instrument to go in any but the desired direction. Having once placed the elevator under the depressed bones, the scalp above the wound is then protected to prevent injury to either the overlying soft tissues or the skull beneath. Then, with the fingers of the opposite

hand placed over the fractured area to follow the progress of the reduction, by simple [illegible] displace it. The temporal wound is closed without drainage with a few interrupted sutures and a sterile dressing applied. Firm bony union in the fracture usually develops within three weeks."

Fractures of the superior maxilla and of the mandible scarcely belong to the field of minor surgery, and their treatment falls into the hands of the oral surgeon and dentist. The first-aid treatment of fractures of the mandible consists in placing a four-tailed bandage on the point of the jaw and fastening

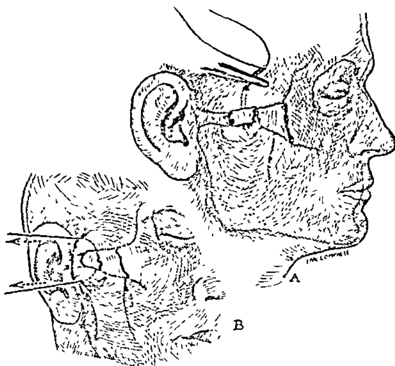


Fig. 123.—Method of elevating a depressed fracture of the zygoma by inserting wire under the fragments with a needle. (Ferguson, L. K.: Surgery of the Ambulatory Patient, J. B. Lippincott Co.)

it tightly over the head to hold the fragments in place (Fig. 124). The patient is then referred to the dentist, or oral surgeon, who, by means of wiring, will attach the lower jaw to the upper jaw and hold the fractured mandible stationary until healing is brought about.[37]

Blows upon the mouth which loosen teeth will cause momentarily a profuse hemorrhage. This is rarely of long duration. It is extremely advisable to try to preserve these teeth. If they are loose, they should not be extracted, and if they are bent out of position an effort should be made to straighten them. The counsel of a dentist is indicated. It is said to be possible for the dentist to replace teeth which have been knocked entirely out of the socket.

Thomas[38] says:

"There are two main points to be kept in mind regarding injuries to teeth: Any injury that *moves the end of the root* of a tooth any appreciable distance in relation to its sur-

rounding bone will cut off the blood supply to the pulp of the tooth and cause the death of the pulp. Such a tooth should always be removed, because otherwise it will be a continuous source of infection. Similarly, a tooth split through its crown into the pulp and a tooth with a fractured root should be removed, although there may be exceptions in the latter case. The proper time for removal of such teeth varies with the circumstances but, in general, they should be removed as soon as the patient's condition will allow, unless they are in the line of a jaw fracture or are needed to guide replacement of fragments of a fractured jaw. In the latter instances, extraction should be delayed until after healing of the fracture.

"*Slight loosening* of a tooth from injury, even though there is no response to an electric test for pulp vitality, does not necessarily mean that such a tooth will be lost; for although, due to the injury, the nerves in it do not conduct sensation, the pulp may still be vital. Over a period of months, either sensation will return, indicating a vital tooth, or the radiograph will demonstrate periapical changes which will indicate extraction of the tooth.

"Teeth of children have larger apical foramina than those of adults and, consequently, can be injured to a greater extent and the pulps still remain vital.

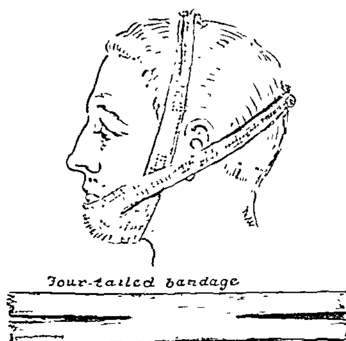


Fig. 124.—Four-tailed bandage used in the first-aid treatment of fractures of the mandible.

"The *cementum* receives its nourishment from the attached membrane and bone surrounding it, but an injury that removes or temporarily interferes with this attachment does not necessarily cause the loss of the tooth, providing the pulp remains vital. In most instances, early replacement of adjacent tissues will result in reattachment to the tooth."

Dislocation of the lower jaw is practically always forward and may be unilateral or bilateral (Fig. 125). The cause may be muscle action alone or a force applied to the widely opened jaw. The accident commonly occurs during the extraction of teeth, when a very large object is placed in the mouth, or during yawning, coughing or laughing. The condyle being already advanced forward, the pull of the external pterygoid and possibly the temporal muscles will bring about the dislocation. This dislocation may be very difficult to reduce. Cotton[39] describes two methods of treatment. The first is the leverage-depression of the angle of the jaw with raising of the chin. "The best way of doing it is to put the two thumbs (protected with a twist of gauze or with heavy thumb cots) in either side of the mouth, to the outer side of the last molar teeth (Fig. 126). Then sharp pressure is thrown upon

hand placed over the fractured area to follow the progress o
levering movements the fragments can be quite easily manipula
tion. In cases of old healed deformities, a similar technique may
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surgeon and dentist. The first-aid treatment of fr
consists in placing a four-tailed bandage on the point

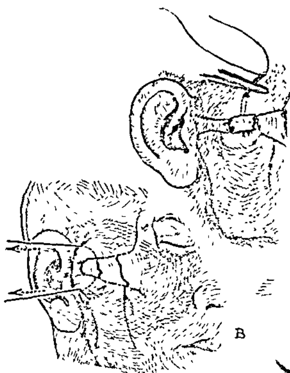


Fig. 123.—Method of elevating a depressed fracture
under the fragments with a needle. (Ferguson, L. K.: Su
J. B. Lippincott Co.)

it tightly over the head to hold the fragments in
is then referred to the dentist, or oral surgeon, v
attach the lower jaw to the upper jaw and holo
tionary until healing is brought about.[37]

Blows upon the mouth which loosen teet
profuse hemorrhage. This is rarely of long dura
to try to preserve these teeth. If they are loose,
and if they are bent out of position an effort
them. The counsel of a dentist is indicated. I
dentist to replace teeth which have been knoc

Thomas[38] says:

"There are two main points to be kept in mind reg
that *moves the end of the root* of a tooth any apprec

widely for a week or two. Certain cases require operative intervention. A case has been reported of reduction after ninety-eight days without incision. (Cotton)

Subluxation of the Temporomandibular Joint.—Clicking or pain at the temporomandibular articulation is due to subluxation and may be very annoying. Schultz[40] has obtained good results in this condition by injecting sodium psylliate (Searle) into the joint cavity. His technic is as follows:

"The ball of the index finger is placed in front of the tragus, and the patient opens the mouth wide enough to cause the head of the condyle to subluxate, 'click' or produce abnormal movement of the fibrocartilaginous disk. The needle is inserted into the joint cavity and from 0.25 to 0.5 cc. of the solution is deposited inside the joint cavity. The injections are repeated weekly or biweekly on both joints until a sufficient fibrosis is obtained. This occurs usually in from three to five weeks. The injections, therefore, number from three to four at the intervals stated.

"The technic of injection should not produce more disturbance than the prick of the needle and a slight feeling of fulness at the time of the injection. Pain usually follows twenty or thirty minutes later, at which time the patient may be given a sedative, or an anodyne may be applied to the parts involved.

"Since the area to be treated contains many important structures, such as the internal maxillary and internal carotid arteries, the middle and internal ear, the brain, the parotid gland and the facial nerve, the course of injection should proceed with due caution."[41] In a later paper, based on over 200 cases, Schultz[42] advises that "both temporomandibular joints should be injected even though the clicking or grating may be present on one side only." Merrifield[43] finds that the sodium psylliate injections are painful and has abandoned them. He first makes certain that there is proper approximation of the teeth. If clicking persists, he then prescribes 1200 mg. of vitamin C daily for a week, then 600 mg. daily for a month and then a maintenance dose of about 100 mg. daily.

BRAIN INJURIES AND SKULL FRACTURES ("HEAD INJURIES")

The inclusion in this volume of injuries with as high a mortality as head injuries might be questioned. They are included, however, because of the high incidence and the infrequency of operative treatment and because the majority of the patients are not cared for by neurosurgeons or in large medical centers. With over 100,000 skull fractures annually in the United States, it is important that as many physicians as possible be acquainted with the surgical principles involved in the care of head injuries. The mortality for skull fracture over the country at large is about 26 per cent (Mock), but with the most approved treatment the mortality is less than half this figure. Fox and Blankstein[44] say that children have a 50 per cent better chance of living after skull fracture than do adults, the respective mortalities being about 8 and 16 per cent. In only 3 to 5 per cent of the cases are there indications for operation. Usually these indications evolve rather slowly; every physician should be familiar with them.[45]

In cases of head injuries, what has happened to the brain is of far more importance than what has happened to the skull. Severe and even fatal injury to the brain may occur without fracture of the skull, and sometimes an extensive skull fracture may be accompanied by inconsequential brain damage, maintained consciousness and few if any symptoms. Voris and his associates[46] say that "approximately 40 per cent of patients dying of head injury have no demonstrable skull fracture at necropsy." "*The gravity of a head injury depends on the degree of damage to the brain.*" (Rand) In 1935 Fay[47] reported 655 cases of head injury. In this series 30 per cent had skull fractures, and the remainder showed blood in the spinal fluid.

hemorrhage, contralateral motor weakness, deepening coma after a period of consciousness (lucid interval), localized twitchings (*jacksonian convulsions or "epilepsy"*) of the face or one arm and increase of the deep reflexes, Babinski's sign and ankle clonus on the hemiplegic side.[85]

Late sequelae in head injuries are always to be kept in mind, but, as Abramson has said, symptoms must not be attributed to previous trauma without proper study. Swift,[86] in a study of 100 cases of head injuries of moderate degree, concluded that in one third of all cases of head injury the patient, after a period of time, does not adjust himself to his present condition. The chief complaints are of headache, dizziness, loss of hearing, loss of vision, localized pain, general weakness, loss of memory and sensory disturbances. Russell[87] followed up 200 patients with head injuries for an average of eighteen months. Aftereffects were found to be commonest in the older patients. The most common post-concussion symptoms were: (1) headache, (2) dizziness, (3) loss of memory or mental ability, (4) nervousness, (5) disturbances of behavior or personality and (6) sleeplessness. One of the most astonishing findings of the author's study was that in 3.5 per cent of persons suffering from postconcussion disturbances, epilepsy develops. Glaser and Shafer[88] conclude that generalized epilepsy occurs in almost 2.5 per cent of the more severe injuries. Bennett and Hunt[89] state that mild cerebral traumatism may cause serious cortical atrophy which may be shown in encephalograms. This is carried out by spinal drainage with air replacement.[90]

Head Injuries in the Newborn.—Monroe[91] studied 117 cases of cranial and intracranial injuries in the newborn. The commonest and most significant symptoms were hypertonicity, abnormal or poor cry, cyanosis and failure to nurse. Other symptoms which were occasionally noted were tense fontanel, apathetic and abnormal respiration, flaccidity, nystagmus, etc. After the infant has recovered from shock and after determination either that the baby is not suffering from a hemorrhagic diathesis or that it has recovered from it through proper treatment, increased intracranial pressure is relieved by repeated lumbar punctures A drachm of saturated solution of magnesium sulfate may be given by rectum. Of 66 newborn infants studied at autopsy, Tyson and Crawford[92] found intracranial hemorrhage to be present in 32 I per cent. In their series the following symptoms were noted: fretfulness, 94 per cent; intermittent cyanosis, 64 per cent; muscular twitchings, 58 per cent, and excessive loss of weight, 85 per cent. Diagnosis is aided by lumbar and cisternal puncture Subcutaneous injection of 20 cc of the mother's blood is of value in the treatment. The spinal fluid is repeatedly drained.[93]

OTHER CONDITIONS

Piercing Ears for Earrings.—This almost obsolete procedure is still occasionally requested. A straight cutting needle is passed through the ear, and after it is drawn silk thread which has been threaded through the needle. The thread is moved daily until the tract through which it is passed has become epithelized; it is then withdrawn. Needless to say these procedures are carried out under strict antiseptic and aseptic precautions. Local anesthesia may be employed.

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CHAPTER IX

INFECTIONS OF THE HEAD

INFECTIONS OF THE SCALP AND THE SKULL

Cellulitis.—Diffuse inflammation of the scalp is spoken of as cellulitis. In this condition there is no centralized infection or localized process, but the bacterial invasion and its inflammatory response are diffuse. Cellulitis is the result of infection through some minute portal of entry which may, however, be so small as to be invisible. The infection may involve only the most superficial layers of the skin, and its rapid spread may be through the lymphatics. Or the infection may involve the superficial fascia, where lateral spread is less likely to occur. Where wounds penetrate the aponeurosis, the subaponeurotic space is involved, and lateral spread of infection may take place. Infections of the scalp occasionally result in septicemia.[1] The treatment of cellulitis of the scalp rests in the cleansing of the area with soap and water, and the industrious application of hot fomentations, preferably of boric acid solution. It is usually unnecessary to clip or shave the hair in mild cases of cellulitis of the scalp. If, however, the infection seems to be spreading despite treatment and if it is of a particularly virulent type, it will be safer to clip and shave the affected area.

Furuncle.—Localized cutaneous infections of the scalp which are well circumscribed and have a central cavity containing pus are known as furuncles. These furuncles may be of various sizes. When very small and in the incipient stage, a prophylactic treatment, which often brings success, is to give the furuncle two or three coats of 7 per cent tincture of iodine, allowing the solution to dry between applications. Well developed furuncles are best treated by continuous fomentations. For this purpose a large pack of gauze saturated with boric solution and kept warm is the most useful. When expediency prevents the utilization of this method, treatment with a softening unguent is to be recommended. It will be advisable in practically all cases to clip the hair over and in the neighborhood of the furuncle. It is desirable to have the furuncle rupture spontaneously. If, however, there is definite fluctuation or a "head," incision with a very sharp, lancet-pointed knife is permissible. Under no circumstances should the affected area be subjected to squeezing or pressure. Particular care must be observed in the prevention of the spreading about of pus on the uninfected skin. The discharge from the furuncle will contain great numbers of staphylococci which, if implanted in hair follicles, may give rise to further furuncles. In chronic cases of recurrent furunculosis of the scalp, an autogenous vaccine made from cultures of the patient's furuncles will be beneficial in about 50 per cent of the cases. The use of tin and x-ray may be tried. (See section on Furuncles and Carbuncles.)

Furunculosis of the External Auditory Meatus.—According to Ballenger,[2] the early use of a 5 per cent solution of carbolic acid in glycerin will occasionally abort early furuncles of the external auditory meatus. In the early inflamed stage of furunculosis, the loose packing of the canal with small

strips of gauze moistened with a 4 to 8 per cent solution of aluminum acetate is valuable. Applying a gauze pack saturated with 1 per cent trinitrophenol or 1 per cent silver nitrate for twenty-four to forty-eight hours and then replacing it has been advised.[3] Galloway[4] uses aluminum acetate, hot packs, "ergophen," sulfathiazole ointment and systemic chemotherapy or penicillin in severe cases. He says that these furuncles often start as a fungus infection. When there is definite pus present, the furunculous area should be freely incised with a narrow bistoury.

Carbuncles of the scalp must be treated with great care, and, for the first twenty-four hours at least, one is more inclined to use conservative measures, such as fomentations and unguents, than to incise. If, however, the process is increasing, it will be necessary to treat it surgically. For this purpose a crucial or six angled incision with undercutting of the flaps and loose packing of the cavity will be necessary. (See section on Furuncles and Carbuncles.)

Subpericranial Abscess.—*Occasionally pus will develop beneath the galea* aponeurotica or beneath the pericranium. Because of the toughness of the overlying layer, fluctuation will be difficult to demonstrate. If the condition is suspected by virtue of the swelling, pain, pulse and temperature, free incision and drainage are indicated. Counterdrainage may be necessary at the dependent portions of the scalp. If this condition is not recognized promptly and accorded proper treatment, osteomyelitis of the skull may result.

[illegible] often be invited to treat nonsurgical [illegible]

Ringworm of the Scalp (*Tinea Tonsurans*).—Ringworm of the scalp is primarily a disease of children. The ordinary form is characterized by gray patches ranging from ½ to 1½ inches in diameter and covered with a slight scale in which can be seen the broken-off stumps of hair. This type in no way resembles a carbuncle. The ringworm lesion, however, which may be confused with a carbuncle is the moist boggy furuncular type known as kerion. This type generally is characterized by a single patch, circular in outline, definitely elevated, and boggy in consistency. Pressure upon it will cause pus to exude from the infected hair follicles. The lesion is a conglomerate, pustular folliculitis produced by the ringworm fungus (ectothrix variety). Symptomatically, pain is not a predominant feature, although the cervical lymph nodes may be enlarged and tender. The treatment is *not* surgical incision. The hair around the swelling should be shaved and hot boric fomentations applied The loose hairs should be removed with a forceps and the part painted daily with *tincture of iodine, or applications should be made of a 5 per cent white precipitate ointment.*

Impetigo.—The type of impetigo commonly seen upon the scalp is a follicular one known as Bockhart's impetigo. This is a superficial suuppuration which may occur on any of the hairy portions of the body and is commonly on the scalp. It may arise *without* apparent cause, or it may follow irritation produced by strong drugs[5] The lesion is a hair follicle infection, purulent from the start, each lesion being perforated by the shaft of a hair and caused by the Staphylococcus aureus. The condition may be limited to a single portion of the scalp, or it may involve it quite generally. The condition is often chronic. The treatment consists of hot boric fomentations followed by applications of a 5 per cent white precipitate *ointment (unguentum hydrargyri ammoniati).*

Herpes zoster is commonly seen involving one side of the scalp. The onset is generally preceded by some neuralgic pain and for a day or two may present some difficulty in diagnosis. Herpes zoster on the scalp is generally the result of an irritative lesion of the posterior root ganglion of the trigeminal nerve. The eruption manifests itself often as isolated groups of flat papules, which become vesicular in a few days. It is attended by [illegible] The diagnosis [illegible]

involved, it may be rather difficult. Depending [illegible]

occupy the vertex, or the occipital portion of the scalp, or it may extend down into the supraorbital region. In this case the eye may be the seat of iritis, choroiditis or retinitis, and extensive damage to the eye may result. The treatment consists in easing the pain, the prevention, if possible, of secondary infection, and the support of the strength of the patient. For this purpose probably nothing is better than hot boric fomentations followed by the use of soothing antiseptic lotions. An example of the latter is:[6]

	Gm. or Cc.
Zinc oxidi	12
Talcum	8
Glycerin	6
Phenol	2
Liquor calcis	120
Aquae rosae	q. s. ad 240

For the relief of pain, aspirin or sodium salicylate should be given in fairly large doses. Potassium iodide injected intravenously is useful.

Osteomyelitis of the skull may result from infections of the scalp (rarely) or from wounds of the skull itself, such as puncture wounds with compound fractures. It may also occur

The dressings should be arranged so that the discharge from the wound is not spread on the adjacent region. The wound itself should not be probed for the presence of a sequestrum. The latter most frequently will discharge itself spontaneously. If this does not occur and its presence is suspected, *x*-ray examination will often reveal it; if it seems to be detached from the neighboring bone, sequestrectomy will be indicated. Cushing says that all of the diseased bone should be rongeured away to undoubtedly healthy bone. Galloway[7] says that anaerobic or micro-aerophilic streptococci can be found in many, if not most, cases of cranial osteomyelitis and advises wide exposure and the use of zinc peroxide.

Syphilis of the Skull.—Gummatous inflammation originating in the pericranium may spread widely in the diploe and bring about syphilitic osteitis, causing the skull to present a worm-eaten appearance. When the gummas become infected and break down, the skull is affected so that there is a considerable area of necrosis and sequestrum formation.

The treatment of cranial syphilis will be antiluetic medication and surgical drainage of the infected area. Sequestrectomy may occasionally be necessary.

Tuberculosis of the Skull.—In describing tuberculosis of the skull Cushing[8] says that "it occurs almost without exception in children, usually as a single circumscribed lesion of the vault; more rarely there are multiple ones. Concomitant foci of tuberculosis elsewhere in the body commonly serve as a tell-tale of the nature of the process. The disease usually starts in the diploe, and the focus of suppuration quickly extends in the child's thick skull, both externally and internally, and leads to the perforating abscess described by Virchow. The subperiosteal 'cold' abscess—soft, fluctuating, covered by reddened skin—frequently opens itself leaving a sinus, at the bottom of which a patch of necrosed bone may be detected. A small sequestrum usually forms, separates early, and may be removed by curettement. The disease often remains limited to the external table. When neglected, these tuberculous abscesses may burrow under the pericranium or aponeurosis and open at a distance, leaving fistulous tracts which are difficult to heal unless widely laid open, thoroughly cleansed and packed. The temporal bone is the most common seat of tuberculous osteitis, the process being secondary to tuberculous otitis media or mastoiditis. . . ."

INFECTIONS OF THE FACE

The general rules which apply to the diagnosis and treatment of cellulitis, furuncles and carbuncles, which were outlined in chapter III, apply with certain exceptions to those conditions on the face. However, all infections of the face, particularly of the upper lip and nostril, are more serious than those in any other region of the skin because of the communications of the inferior and superior angular veins with the cavernous sinus (Fig. 127). Infections involving these veins may extend to the cavernous sinus, with fatal results. (See the section on Furuncles and Carbuncles.)

"The dangerous area of the face is the triangle which extends roughly from the angles of the mouth to the bridge of the nose. . . . There is a direct connection between the veins of the lip and the facial vein, which empties into the ophthalmic vein, which communicates, in turn, with the cavernous sinus. The angular vein thus serves to connect the superficial venous system with the deeper intracranial venous channels, furnishing a short direct

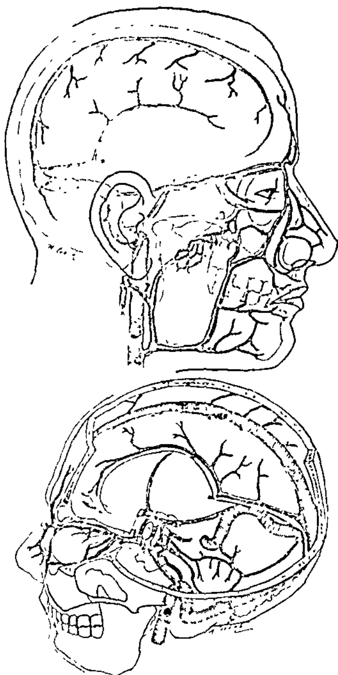


Fig. 127.—Note anastomosis at upper inner angle of eye between superficial vessels and the superior ophthalmic vein, and the connection between the deep pterygoid vessels and inferior ophthalmic vein. None of these veins has valves. (Cutler, Elliott C., in discussion of paper by *Coller, F. A., and Yglesias, L.:* Surg., Gynec. & Obst. 60:277, 1935.)

Access is simplified furthermore

Hinton[10] has made clear the anatomic proximity and relations of th anterior facial vein and its branches to the cavernous sinus. From the facia vein, blood and organisms can pass by way of the inferior ophthalmic vei and the angular and superior ophthalmic veins by a sort of retrograd thrombosis. The mortality for furuncles of the *face* has been variously esti mated. Of 1903 cases treated on Payr's service in the period from 1913 t 1924, 10.7 per cent were fatal.[11]

Cabot's[12] case is illustrative of the grave danger of traumatism in case of furuncle of the upper lip. A boy of 17 years picked a small pustule of th upper lip. The next day a small incision was made. Tremendous swellin then developed, and the patient became stuporous. The white blood cel count varied between 23,000 and 39,000, and when the patient died, si days later, there was pus in the cavernous sinuses. In Comer's[13] case th patient picked and squeezed a furuncle of the anterior nares, and deatl ensued three or four days later. Turner and Reynolds[14] report 1 death i 63 cases of furuncle of the nasal vestibule, a mortality of 1.5 per cent. In th fatal case a small boil appeared upon the inner aspect of the right ala nasi Two days later it burst, with a free discharge of pus. On the following da headache, vomiting and protrusion of the eyeballs occurred. Death resulte six days after the onset.

Dittrich[15] found that in 22 of 40 cases of furuncle of the upper lip treate by incision, the mortality was 13.6 per cent, whereas in 18 cases in whic incision was not done, the mortality was only 5.5 per cent. This autho feeds the patient through a tube and prohibits speech, in order to keep th affected parts at rest. Melchior[16] collected reports of 73 cases of facial furun cles at the Breslau clinic. In the 37 cases treated by incision there were deaths, and in the 36 cases treated conservatively there was but 1 death.

The risk of infection in the "dangerous area" is further increased by th fact that a patient almost invariably traumatizes a pimple by squeezing o picking it. The trauma is probably the origin of the spread, which continue by thrombophlebitis. The causative organism is practically always Staphyl ococcus aureus. The pimple grows into a furuncle, which in turn develops int a spreading infection, with final cavernous sinus thrombosis. The temperatur is high (105 to 107°F.). The course, in fatal cases, is often less than twenty four hours and seldom more than five days. Maes reported 20 fatal cases o infections of the dangerous areas of the face and added reports of 24 fata cases of infection of other areas of the face not usually included in th dangerous area. Chatterji and De[17] reported 55 cases of facial cellulitis with a mortality of 80 per cent. Prophylaxis is of the utmost importance i cases of infection of the face. All physicians should urge their patients no to squeeze pimples on the face or to attempt to open them.

Ultraconservative treatment is indicated in all of these cases of seriou infection. The patient should be in bed, preferably in a hospital. Speech o any movement of the lips or face is strictly forbidden. Only liquid nourish ment is given, and Maes recommends that it be given through a nasal tube.

All such infections should be treated by warm fomentations, with car to avoid burning the patient. It is very difficult to have such hot fomentation properly applied without very specific directions and without the aid of a attendant or nurse. In furuncles and carbuncles of the upper lip it will b advisable to place a large pack of gauze saturated with boric solution ove

the area and surrounding parts. The common error is to make these packs too small. If the furuncle is on the upper lip, the pack should extend over the eye on the affected side, below the chin to the anterior margin of the ear and over the mouth and nose, leaving only a corner of the mouth exposed for breathing (Fig. 128). These packs should be changed every fifteen minutes if possible, or, what is more efficient, they should be covered with waterproof material, such as rubber sheeting or oiled silk, and over this an electric pad should be fastened in place so that continuous moist heat is secured.

The *sulfonamides* should be used in adequate dosage. (See section on Sulfonamides.) In a very severe case, resistant to sulfadiazine, Herrell and his associates[18] had a brilliant result from the use of *penicillin*. Twice daily for two days, 116 mg. of penicillin dissolved in 1000 cc. of physiologic saline solution was given by continuous intravenous drip (25 to 30 drops per minute).

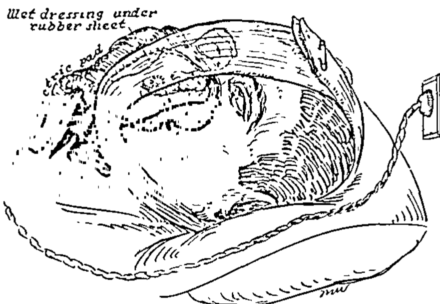


Fig. 128.—The technic of hot boric acid fomentations for a furuncle of the upper lip A large-sized gauze pack, saturated with boric acid solution, is placed over the cheek, mouth and nose. Only a small corner of the mouth is left open to permit breathing. The gauze pack is covered with rubber sheeting, and an electric pad is placed on top. The gauze, sheeting and electric pad are held in place by a pinned towel.

Twenty-two hours after the start of this treatment the blood culture was sterile, and the patient rapidly recovered. (See section on Penicillin.)

Incision is not indicated. The trauma of incision has very much the same danger as squeezing or picking. Maes,[19] in discussing infections in the dangerous area of the face, says, "Surgical nihilism is a plan that is generally distasteful to patient and physician alike, but this is one disease in which it is the only type of therapy not attended by a tragic death rate." He has used staphylococcus antitoxin and believes that it has real value. Roeder[20] has devised an apparatus which is applied to the face in such a manner as to obstruct by pressure all veins entering the orbit. Operation on the cavernous sinus has been successful on one or two occasions.

Furuncles of the nose deserve the same degree of conservative care. These small infections in the alae nasi are extremely painful because of their proximity to the cartilaginous plates of the nose. The patient is greatly tempted

and often does squeeze these furuncles in the effort to express pus, with the result that the infection is widely disseminated, even to the extent of a fatal result. (See the section on Furuncles and Carbuncles.) The best treatment is that of continuous hot fomentations. Should this be inexpedient, however, it will be advisable to place in the nostril white vaselin or unguentum hydrargyri ammoniati in an effort to facilitate and hasten discharge of the furuncle into the nostril. Furuncles of the external auditory meatus are extremely difficult to treat with fomentations. However, this treatment may be of some benefit.

In the treatment of mycotic diseases of the external ear, Whalen[21] suggests the following: "The canal is cleaned of débris and dried by means of a current of warm air. It is packed with cresatin for twelve hours. A solution of thymol in alcohol, 1 per cent strength, is used for a five minute period twice a day for five days. At the end of five days thymol iodide powder is dusted into the canal three times a day for three days. Potassium iodide is administered orally to the amount of 30 grains a day for thirty days."



Fig. 129.—Hordeolum (stye). (Children's Memorial Hospital, Chicago. Service of Dr. Richard Gamble.)

Stye.—A stye or hordeolum is a localized staphylococcic infection or abscess of the lid margin which originates in one of the sebaceous follicles of the lashes (Fig. 129). Cold compresses will occasionally abort a stye. When it is evident that the stye cannot be aborted, hot compresses are useful to hasten the suppuration. As soon as a yellow spot is seen, "the pus should be evacuated either by pulling out a lash, or by horizontal incision and then squeezed out."[22] Five per cent sulfathiazole ointment or 1 per cent yellow oxide of mercury ointment placed in the conjunctiva and rubbed into the lid margin is a valuable remedy in the treatment of styes. Sulfonamides systemically are indicated in severe cases. All patients suffering with styes should be referred to an ophthalmologist for examination. Errors in refraction are believed to have an etiologic bearing upon styes. The exhibition of tin or calcium sulfide internally may be indicated. Institution of measures designed to improve the general health are of importance.

Acute Dacrocystitis.—A stye should not be confused with acute dacrocystitis or inflammation of the lacrimal sac. The latter condition is manifested

by a tender red swelling of the skin over the sac. When, after two or three days, an abscess has formed, it is opened by a free incision pointing downward and outward. The incision is loosely packed with gauze. Incomplete healing will occasionally bring about the existence of a lacrimal fistula. Sulfonamides or penicillin should be used in severe cases. In some cases it is advisable to extirpate the sac, but never until the acute symptoms have entirely subsided.[22]

Erysipelas is a cutaneous infection due to streptococci which tends to spread through the lymphatic system. (See section on erysipelas under Open Wounds.) It is particularly common upon the face. It will not develop without the presence of a small wound, which, however, may be so small as to be invisible. It may originate from the picking of a small pimple on the face or in the corners of the nostril. The initial symptom is usually a chill. *The patient has an unusual elevation of temperature, 103 to 104°F., and a* marked degree of prostration. The involved area spreads laterally with a sharply demarcated, wavy and slightly elevated border. The average duration of the disease is two weeks, and exacerbations are frequent. Because of the infectious nature of this ailment, it is always to be treated by isolation of the patient and the observance of antiseptic precautions on the part of the attendants. The patient will be put to bed at complete rest with a bland diet and the pushing of fluid.

In the treatment of erysipelas, sulfanilamide has become a valuable agent and should be promptly emp oyed. For details of its administration, see the discussion of sulfanilamide in the chapter on open wounds. Foley and Yasuna[23] studied the use of sulfanilamide in erysipelas and concluded as follows:

> "In eighty cases of erysipelas sulfanilamide treatment was given and the results were compared with those in eighty similar cases in which sulfanilamide was not used. It was found that the drug treated patients returned to a normal temperature almost two days earlier than the control. The hospital stay was shortened three days for the sulfanilamide treated patients. [illegible] control group as in the treated group. [illegible] that of the untreated group [illegible] kidney shut-down after the erysipelas had been brought under control It is possible that they represent complications of sulfanilamide."

The local applications which are most suitable are cold solutions. *Of these* iced boric solution is probably the best. Of recent years great encouragement has been reported following the use of antistreptococcic erysipelas serum. (See Chapter II.) *x*-Ray has also been useful.

By the term phlegmonous erysipelas is meant those very virulent types of erysipelas infection which involve the entire thickness of the skin. These infections result in necrosis and are extremely dangerous. The treatment, which belongs to the domain of major surgery, is debatable. Most surgeons somewhat reluctantly employ multiple free incisions preferably by the actual cautery.

Otitis Media.—Infections of the middle ear, which are particularly prevalent in children and are characterized by preexisting or coincidental infections of the respiratory tract, elevation of temperature, pain in the ear and a bulging, red tympanum, will require paracentesis. Early incision of the tympanic membrane will often avert inflammation of the mastoid.

According to Ballenger[24] "incision of the membrane tympani is an almost

ideal therapeutical measure in the early or preperforative stage of acute suppurative otitis media, though it is of less value in the later stages of the disease, and in the chronic type. In such cases the establishment of free drainage and the total removal of the morbid material should be accomplished. In acute cases the incision of the membrana tympani should be long and curved, to permit the secretions to flow through it." The operation should be performed as soon as there is bulging of the tympanic membrane. The external auditory canal should be cleansed with 1:4000 bichloride solution before the puncture. Partial anesthesia may be obtained by dropping 2 or 3 drops of a solution composed of equal parts of hydrochlorate of cocaine, menthol and carbolic acid into the auditory meatus. General anesthesia may be indicated. The best instrument is a curved bistoury. The simple puncture is inadequate, but a long curved incision is proper and should be made in the posteroinferior quadrant (Fig. 130). After the incision has been made, the canal should be loosely packed with gauze two or three times daily until the discharge ceases.

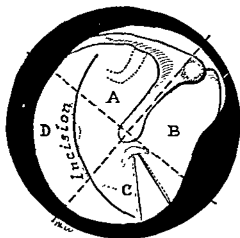


Fig. 130.—Diagram of the tympanum showing the landmarks and the most favorable site for paracentesis. (After Ballenger.)

Peritonsillar Abscess; Quinsy.—Some cases of tonsillitis are complicated by the formation of an abscess in the connective tissue adjacent to the tonsil. There is fever, and marked prostration is present. The diagnosis may be made by the extreme pain in this region which radiates to the ear, by the difficulty in swallowing, and by the red, bulging prominence generally in the soft palate above the tonsil. Gentle palpation may demonstrate fluctuation. Inasmuch as early manipulations are dangerous, the incision had best be deferred until there is reasonable assurance that free pus has developed—generally thirty-six to forty-eight hours. A sharp-pointed knife is used and is so covered with adhesive tape that but ¼ inch of the knife projects beyond the adhesive covering (Fig. 131). The abscess is opened by means of an incision "through the anterior pillar at the superior pole."[25] Hot throat irrigations (sodium bicarbonate, 1 drachm to 1 quart of water) are useful in allaying pain until the incision is made. A hot saline irrigation with a crooked glass tube is very comforting. Sulfonamides or penicillin should be used in severe cases. If the abscess forms posteriorly to the tonsil, Brighton[25] advises removal of the involved tonsil.

Numerous types of fatal consequences have resulted from peritonsillar abscesses, and, of late, writers have been prone to recommend earlier incision. Greenfield[26] says that an appreciable amount of pus is usually present on the third day. This author employs a vertical incision over the point of maximum swelling. Stenger[27] advises prolonged expectant treatment and describes a special type of incision. The tonsil is separated from the palatal arch until the posterior surface of the tonsil is reached, a maneuver which usually causes the abscess to open of itself. Nagel[28] advises exact localization before incision, even at the expense of tolerating the condition a day or so longer. This author believes that tonsillectomy is indicated only in cases in which there is frequent relapse, and then only when the acute inflammatory stage has passed.

Dobbs,[29] who says that 90 to 95 per cent of all quinsies are supratonsillar, recommends a method of opening peritonsillar abscesses by means of a "series of probes, the first having a small blunt end. This is followed by a larger instrument which is threaded. The *threaded instrument readily takes hold as it is screwed in, following the smaller opening* already made. Very little pressure is necessary to enter the cavity and when the instrument is abruptly withdrawn leaves a larger opening than one made by a smooth instrument. The opening can then be enlarged as required, using a larger probe or a small forceps."

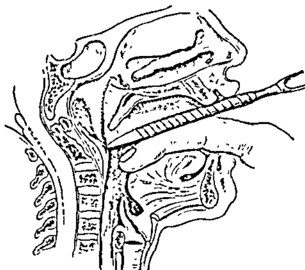


Fig. 131.—Incising a retropharyngeal abscess with a cotton-covered scalpel. (Moorhead, J. J.: Traumatic Surgery, ed. 2, Philadelphia, W. B. Saunders Co., 1923.)

A new method of inducing anesthesia for the alleviation of pain on incision of a peritonsillar abscess is described by Guttman:[30] "A 10 or 20 per cent solution of cocaine or a 2 per cent solution of nupercain is applied by means of a cotton-tipped applicator to the region of the sphenopalatine ganglion, namely, just behind and lateral to the posterior end of the middle turbinate."

Retropharyngeal Abscess.—Children with acute infections of the respiratory tract are occasionally subjected to the unpleasant sequel of retropharyngeal abscess. In this condition a collection of pus occurs in the submucous connective tissue of the pharynx. The usual symptoms of abscess formation are present. Dysphagia and dyspnea will be present, and the child will present a sort of stertorous type of respiration due to the partial occlusion of the upper passages. The cry is peculiar and has a quacking character. Gentle palpation of the posterior wall of the pharynx will generally indicate the diagnosis. Care must be taken either that the palpating finger is wrapped with protecting gauze or that a mouth gag is inserted. The treatment of this condition is entirely surgical. If untreated, it is almost invariably fatal. "If untreated, the abscess may rupture spontaneously during sleep and cause

death by suffocation, or produce suffocation or fatal inanition without rupture."[31] Generous incision in the median line should be made when fluctuation is apparent, although it is unnecessary to wait for fluctuation if other diagnostic signs are present (Fig. 131). Guthrie[32] merely plunges into the swelling a long sinus forceps or a peritonsillar forceps and opens the blades in a vertical direction. It is important that the child's head be placed in a dependent position to lessen the likelihood of aspiration of pus. No anesthetic should be used, and the operation should be carried out as rapidly as possible. If a general anesthetic is used, suction must be employed to remove the pus and blood.

In the Children's Hospital, Boston, Richards[33] saw 162 patients with *retropharyngeal abscesses* in ten years, with a mortality of 7.4 per cent. Only constant consideration of this type of abscess as a possible explanation for a wide range of symptoms will prevent diagnostic errors. Careful digital palpation of the pharyngeal wall is preferable to the use of a tongue depressor or mouth gag. Pharyngeal incision, without anesthesia and with the patient prone, will suffice to secure drainage in almost all cases. Sudden severe hemorrhage must at once be controlled by ligation of the carotid artery. (Richards.) Deering and Brenneman[34] report 250 cases of true or potential throat abscesses in children, with a total mortality of 1.7 per cent; the mortality following retropharyngeal abscess alone was 2.4 per cent.

Alveolar Abscess or Gum Boil.—In this condition there is a localized collection of pus at the alveolar border, which has resulted from infection at the root of a tooth. The abscess is readily recognized by swelling and redness of the gum border and by the marked pain. It is preceded by a throbbing toothache. According to Vaughan and Burnham,[35] "the pus, having formed, may discharge through the root canal of the decayed tooth or between the tooth and the gum, in which event the condition is rarely seen by the surgeon. In other cases the pus may dissect up the periosteum and appear beneath the mucous membrane at the side of the alveolar process and perforate directly through the bone to the external surface of the bone (rarely to the internal); or it may extend along the body of the bone causing an extensive osteomyelitis of the jaw."

When the process is still confined to the tooth, the services of a dentist will be required. The tooth will be extracted, or a hole will be drilled to permit the evacuation of the pus. When the presence of fluctuation is definitely established, incision is indicated. Very frequently fluctuation will not be present, and the indication for incision will depend upon the presence of swelling and tenderness. The pain of the incision is somewhat lessened if the mucous membrane over the abscess is painted with a 4 per cent cocaine solution. The injection of a local anesthetic not only is painful but introduces the danger of dissemination of infection. The incision should always be through the mucous membrane unless it is absolutely necessary to make it through the skin. The incision should be parallel to the gum border and is best kept open by a small selvedged gauze drain for a day or two.[36] Meleney[37] believes that "zinc peroxide should be used as a prophylactic mouth wash in all cases preliminary to tonsillectomy or dental extraction" with the object of preventing serious infections of the mouth.

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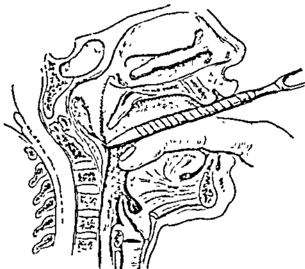


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Acute Glossitis.—Fortunately, acute glossitis is a rare condition, but when met with it is both serious and alarming. It has arisen after wounds of the

tongue or following sore throat or tooth infection. The tongue *may swell* rapidly and become so large as to embarrass respiration through the mouth. It will be stiff and tender. There is an increased flow of saliva from the enlarged and tender submaxillary and sublingual glands. The saliva cannot be swallowed and will trickle out of the mouth. The swelling may subside quickly, or in the more severe cases death may supervene in a few days.

"*The treatment of acute glossitis should be energetic if the* urgent symptoms detailed above are to be avoided. If any cause such as a bad tooth can be found, this should be removed. Antiseptic and emollient mouth washes and gargles should be used at once. In severe cases, however, there seems to *be no treatment like a longitudinal incision into the tissues of the tongue.* The incision need not be deep; it need only divide the mucous membrane which contains the tongue and so lessen the edema. Fluids can be given through a catheter down the throat."[38] Galloway[39] advises use of penicillin or chemotherapy and warns that the surgeon must be ready to do a tracheotomy, *must watch the fluid intake carefully and must be on the alert for* signs of anoxia.

Glossitis Rhombica Mediana.—According to Martin and Howe,[40] this is "a benign disease of the tongue characterized by the presence of a mass or plaque, ovoid or rhomboid in shape, situated in the midline of the tongue, just anterior to the V formed by the vallate papillae. There are usually no subjective symptoms, and the condition is commonly discovered by the physician or dentist, or even by the patient himself, in the course of an incidental examination of the oral cavity." The clinical diagnosis, with the distinction from cancer, is made by the unique position of the lesion. No treatment is indicated except when the patient is fearful of cancer, in which case surgical excision may be carried out.

[illegible] but serious condition. Bernardini[41] [illegible] fatal. [illegible] illitis, typhoid, variola, erysipelas, thrush, tonsillectomy, molar extraction, and erosions and wounds of the tongue. The diagnosis is made from swelling and pain in the tongue referred to the jaw, head or ear. The differential diagnosis must include actinomycosis, allergic macroglossia, anthrax, leprosy, salivary gland calculus, stomatitis and syphilis. Grigsby and Kaplan[42] have studied this subject and conclude that an abscess of the tongue should be promptly and adequately incised, with a posterolateral incision. It is thought by some that the presence of pus must be made certain by exploratory aspiration before the incision is made. Care must be observed in the use of a general anesthetic. Fitzwilliams records the case reported by Butlin and Spencer, in which "while an anesthetic was being given as a preliminary to incising an abscess, this burst into the larynx and caused the death of *the patient.*" *Sulfonamides and penicillin are employed in the treatment of abscesses of* the tongue.

Gangrene of the Tongue.—This is extremely rare, and perhaps no case has been reported in modern times. Fitzwilliams reports the case of Margaret Cutting, who was presented before the Royal Society in 1742, as follows: "She lost her tongue in consequence of a 'cancer' when she was four years old. She resembled Pritchard's case in that a black speck appeared on the front of her tongue and soon ate its way to the root. She was under medical treatment all the time, and one day when the mouth was being syringed the tongue dropped out into a plate, and Margaret said, 'Don't be frightened, mamma; it will grow again.' As the tongue in those days was thought to be the essential organ of speech, the amazement of those present may be imagined. The stump took nearly three months to heal."

Acute Pyogenic Parotitis (See also Postoperative Parotitis).—This affection generally occurs as a complication of a postoperative state or an acute infectious disease. It is an extremely dangerous postoperative complication. Furstenberg[43] says: "Prominent among the causative factors responsible for parotid inflammation are foreign bodies in Stensen's duct, particularly

the calculus; injury or disease of the abdomen or pelvis, and extension of infection from neighboring tissues. Whatever the exciting cause of the abscess may be dehydration and injury are potent influences in its development and progress." It is much more common in patients who have been obliged to fast for several days. Talbot[44] says, "The rational prophylaxis is based upon the maintenance of mouth hygiene and a free flow of saliva." There is a tender swelling at the site of the parotid gland. There may be fever, chills and marked swelling. Frank pus may flow from the duct. In 35 cases Blair and Padgett[45] found the mortality to be 42.8 per cent. Hot fomentations are of value. "The patient should be operated upon as soon as it appears probable that the infection will not subside spontaneously."[46] Furstenberg[43] says: "One cannot avoid the hard way of treating parotid abscesses, namely, by wide incision which secures massive drainage. It is the most charitable method in that it minimizes suffering and hastens the patient's recovery. A practice that must find a permanent place in the treatment of infections of the parotid glands is the institution of thorough hydration. There is no compromise for this therapeutic measure." Noticeable scarring is prevented by placing the greater part of the skin incision in the angle at the junction of the cheek with the ear. (Ivy.) Wiesen[47] says:

> "It is not advisable to wait for frank fluctuations before incision. Because of the dense parotid fascia, necrosis and gangrene may ensue before true fluctuation can be obtained. The incision which gives the best immediate and end results is a longitudinal one a fingerbreadth in front of the external auditory meatus. The incision is carried down to the fascia, and blunt forceps are pushed into the gland until pus is obtained. In this way there is no danger to the branches of the facial nerve, or any vessels. If the individual case seems to merit it, there is no objection to two or even three incisions, with through and through drainage." Hot dressings and irrigation are of value.

Hobbs and Sneierson[48] carefully dilate Stensen's duct, and then they irrigate it with normal saline solution only. Rankin and Palmer[49] advocated the use of a radium pack. Leithauser and Cantor[50] believe that the "most effective method of treating secondary parotitis is with massive doses of Lugol's solution . . . , administered orally, by vein and hypodermoclysis. The average daily dose is 160 minims, 20 minims every three hours day and night. In fulminating cases, an additional 1 or 2 drachms of Lugol's solution are given intravenously or subcutaneously, in saline or glucose; 1 drachm to the 1000 cc." Latchmore and his colleagues[51] have been favorably impressed by the use of deep *x*-ray therapy in 11 cases of suppurative parotitis. McCormick[52] reports 20 cases of suppurative parotitis and finds that 200 Kv. *x*-ray therapy was practically a specific treatment if instituted promptly and if combined with suitable supportive measures. Galloway[53] advises using penicillin or sulfonamides but not in connection with *x*-ray therapy, which may decrease the effectiveness of these agents.

Sialolithiasis.—Salivary calculi occur in the cystic dilatation of the salivary glands. In 1926 Harrison[54] collected reports of 375 cases from the literature and added 27 of his own.[55] Calculi are said usually to form about foreign bodies or mouth fungi (Leptothrix buccalis) which have accidentally passed into the ducts. The stones usually consist of calcium carbonate and phosphates and rarely of inspissated saliva. According to Abrams,[56] the most frequent site of salivary calculi is the submaxillary gland. The parotid is next in frequency and the lingual least of all. The symptoms are characterized by periodic

pain in the area of the gland involved. In some cases there are scarcely any symptoms until the duct and gland become infected. The diagnosis is based on the history, the situation of the lesion, the *x*-ray examination and the introduction of sounds into the duct. Payne[57] defines *sialography* as "the radiographic demonstration of the ducts of the salivary glands by means of the injection of substances opaque to the *x*-rays." This author injects lipiodol by means of a syringe made of fine glass tubing drawn out to 1 mm. in diameter. The orifice of the duct is sought *in the region of the second upper* molar tooth. "If necessary, one or two of the graduated cannulas may be passed into it to dilate it slightly. In cases where the duct orifice cannot be identified, or where it is impossible to pass even the finest cannula, the patient is given a piece of lemon to suck. After this has been done there should be no difficulty in localizing the orifice." The saliva will show plugs of mucus or even pus at the time of the exacerbations. The primary object *of the surgical treatment is the relief of the obstruction to the flow of saliva.* (Ivy.) The stone, if present, should be removed by incision into the duct from the mucous membrane. Good results have followed slitting the constricted meatus of the duct in chronic obstructive inflammation without stone. Brooks[58] reports an interesting case of multiple salivary calculi of the sublingual gland.

Salivary Fistula.—In wounds of the cheek Stensen's duct may be severed. *If this wound of the duct is within ¾ inch of the buccal mucous membrane* and if there is a coincident wound of the buccal mucous membrane, a salivary fistula to the inside of the mouth will form, and the patient will be substantially cured. If, however, this does not occur and a salivary fistula forms with external discharge, a plastic operation to reunite the severed ends will be indicated. This extremely difficult procedure belongs to the realm of major surgery. Portmann[59] reports that irradiation may bring about cessation of *drainage in a parotid fistula.*

It is important in all wounds of the cheek, which may or may not involve the salivary duct, *not* to suture the mucous membrane. Carefully applied horsehair or fine "dermal" sutures coapting the skin and immediately underlying tissue should be placed. Suture of the mucous membrane invites collection of pus in the wound and the possible subsequent discharge externally. This, of course, will make an uglier scar.

Infections of the Antrum.—Diseases of the air sinuses of the face will generally require the services of a rhinologist for operation, irrigation or drainage. The recognition of their existence depends upon the presence of facial pain and tenderness and *x*-ray examination. In the case of the infection of the antrum of Highmore, transillumination of the mouth will reveal a dark area in the antrum. The application of warm fomentations is a useful first-aid measure.

Necrosis of the Jaw and Sinuses from the Teeth.—Carious teeth will often cause a draining sinus at the alveolar border and may even involve the tooth sockets themselves, causing osteomyelitis. Osteomyelitis of the jaw may also be caused by fractures, which, of course, are accompanied by wounds of the overlying mucous membrane. *Many of these conditions will clear up* following extraction of the affected tooth and the use of mild alkaline antiseptic mouth washes and hot fomentations. It is advisable to try irrigations with zinc peroxide solution.[60] Pus pockets should be evacuated. When

necrosis occurs, it is better to wait for the natural separation of the sequestrum than to attempt to remove the diseased bone.

Of 489 patients admitted to the Division of Oral Surgery of the Cook County Hospital, Chicago, 128 had acute infections about the jaws, 154 had fractures, 108 had tumors and 65 had plastics. Schaeffer[61] studied 75 cases of severe infection of the jaw. In ten cases he obtained pure cultures of streptococci. In 64 cases the infection was mixed; staphylococci, streptococci (hemolytic and nonhemolytic) and fusiform bacilli were found. In Schaeffer's very interesting paper are described a number of fatal cases of infection originating from tooth extractions. His observations lead him to believe that the dentist who happens to encounter one of these severe infections is just unfortunate and cannot be held responsible for introducing the organism, although by intervention or nonintervention he may alter the course favorably or unfavorably (Fig. 132).[62]



Fig. 132.—Ludwig's angina with laryngeal obstruction following tooth extraction. Note the sublingual edema and the thickened tongue. (Schaeffer, J. E.: Bull. Chicago Dent. Soc., 1931.)

Suppurative Phlegmon of the Floor of the Mouth.—Wassmund[63] asserts that according to reports in the literature the mortality rate in phlegmonous suppuration of the floor of the mouth is about 40 per cent. He, however, obtained better therapeutic results. He gives a tabular report showing the number of cases that came under his observation in 1927 and 1928. A considerable number developed at the time of the influenza epidemic. In discussing the anatomic conditions in suppurations of the floor of the mouth the author states that the majority develop from suppurative processes in the lower jaw, especially from carious teeth. The suppuration spreads from the bone to the softer tissues. If the pyogenic micro-organisms pass through the lymph vessels and nodes, the process is usually less virulent and generally develops in the form of an abscess. One hundred and forty-three of 178 cases of suppurations of the floor of the mouth which were observed by the author were abscesses, whereas in the other 35 cases the suppuration was of the phlegmonous type. The latter form develops if the suppuration spreads directly from the bone to the loose connective tissue. The mortality rate in the phlegmonous suppurations was 11.9 per cent, but there was not a single

fatality among the 143 patients in whom the suppuration was of the abscess form. Following a more detailed discussion of the anatomic conditions the author discusses the therapy. He stresses that all suppurative foci should be opened and drained. In the last part he also discusses the various etiologic factors. He mentions infected extraction wounds, mistakes or accide ts in local anesthesia, and osteomyelitis of the lower jaw. Wintrub[64] has had



Fig. 133.—Chancre of the lip. (Courtesy of Dr. Edward A. Oliver.)

favorable results in mouth infections with the use of zinc peroxide. Penicillin should be used. (See also sections dealing with Ludwig's angina and the use of sulfanilamide and zinc peroxide.)

Chancre.—The primary lesion of syphilis is occasionally found on the face, more commonly on the lips. The diagnosis is based on the presence of a hard indurated ulcer (Fig. 133) and by the positive dark field examination. The treatment, of course, is limited to general antiluetic therapy.

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CHAPTER X

TUMORS AND DEFORMITIES OF THE HEAD

BENIGN TUMORS OF THE HEAD

Comedo.—A comedo is a blackhead or a plug of dried sebum in an excretory duct of the skin and, according to Dorland, occasionally contains Demodex folliculorum. According to dermatologists, the removal of comedones is best effected by pressure with a small metal instrument, so shaped that there is a small ring at the end. The pressure with the ring causes a uniform force about the margin of the comedo and expresses it. The expressor and the skin surface should first be sterilized. The expression of comedones has always seemed dangerous to me and a violation of good surgical principles. Occasionally a virulent infection of the face will result from the trauma incident to the squeezing.

Sebaceous Cyst (*Atheroma, Wen*).—A sebaceous cyst is a retention cyst which has apparently been caused by the obstruction of the duct of a sebaceous gland and the consequent accumulation of sebum and desquamated epithelium. It may be found in practically any portion of the body. Caylor[1] *made a special study of 236 cases in which sebaceous cysts had been excised* at the Mayo Clinic and found the regional distribution to be as follows:

Site	*Per Cent*
Abdomen	2.16
Arm	0 87
Axilla	3.03
Back	4.32
Breast	5 62
Buttock	3.46
Cheek	9.51
Chest	4 32
Ear	0 43
Face (including forehead, cheeks, jaws, lips and parotid region)	16.01
Fingers	1.29
Forehead	3 03
Hand (palm)	2.59
Jaw	1.29
Leg	0 43
Lip (lower)	0 43
Lumbar region	0 87
Mastoid region	1.29
Neck (including back and front)	14.71
Parotid region	1.73
Scalp	28.13
Scrotum	0 87
Shoulder	4 76
Thorax (including front and back of chest and breasts)	14 28
Temporal	2.16
Thigh	2.59

It will be seen from the above table that the scalp is the most frequent site of the cysts, with the face and neck next in order of frequency (Fig. 134). As many as 22 cysts have been removed from the scalp at a single sitting.[2] The cysts vary in size from that of a pea to 7 or 8 cm. in diameter. The



Fig. 134.—Sebaceous cyst of the face. (Surgical Dispensary, Northwestern University Medical School.)

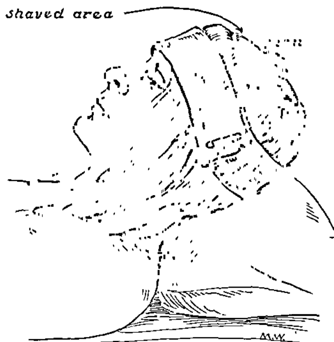


Fig. 135.—Preparation of the field of operation for excision of a wen of the scalp. The skin is shaved about the wen and is painted with antiseptic solution. The hair is held out of the wound by a pinned towel.

lining sac is composed of flat epithelium, and a cure is not effected until this sac is completely removed. Not uncommonly a cyst becomes infected, in which event it swells and becomes tender and the contents are evacuated either spontaneously or through an incision. At the time of the discharge of

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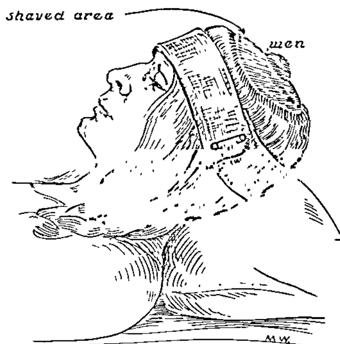


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lining sac is composed of flat epithelium, and a cure is not effected until this sac is completely removed. Not uncommonly a cyst becomes infected, in which event it swells and becomes tender and the contents are evacuated either spontaneously or through an incision. At the time of the discharge of

pus, occasionally it is possible to grasp the sac with a hemostat and remove it entirely. The process then subsides but recurs frequently until the cyst has been removed. These cysts are more liable to occur in the later years of life.

Some 3.44 per cent of the cysts in Caylor's series became malignant. Ulceration or recurrence of the lesion makes excision mandatory. Bishop[3]

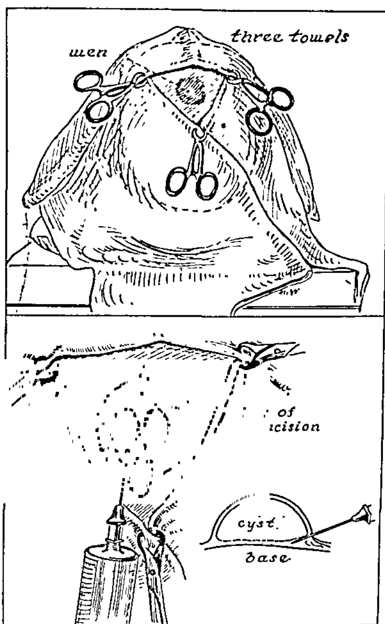


Fig. 136.—Draping of the field of operation preparatory to excision of a wen of the scalp. Infiltration of the elliptical incision with a local anesthetic. Infiltration of the scalp at the base of the wen.

found carcinoma in 9.2 per cent of a series of 119 sebaceous cysts and keratomas. Carcinoma was found to be greater in the female than in the male in the proportion of 8:3. Broders and Wilson[4] differentiated sebaceous cysts and keratomas, both commonly called wens. They stated that "true sebaceous cysts contain a fatty material which gives off a strong odor. Keratomas, on the contrary, unless infected or badly degenerated, are practically odorless.

Many lesions, diagnosed sebaceous cysts or wens clinically, when examined microscopically are found to be made up for the most part of keratin and not sebaceous material. There is considerable evidence to support the belief that these lesions are tumors that rise in the ducts of the sebaceous gland rather than from the sebaceous gland proper. For such tumors we believe that keratoma is a more accurate term than sebaceous cyst."

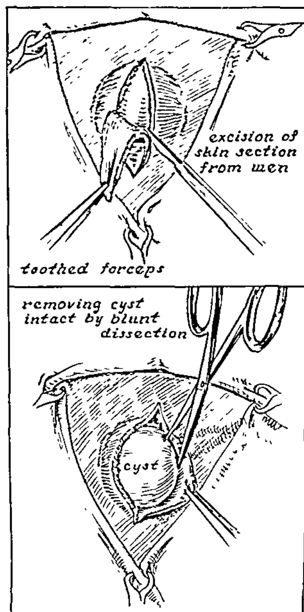


Fig. 137.—Excision of elliptical piece of skin. It is preferable to leave the elliptical piece of skin *attached* to the underlying cyst. Below: freeing wen from its attachment by blunt dissection. The scissors points are carefully divulsed.

Sebaceous cysts may be distinguished from lipomas by the absence of lobulation ("signe de peau d'orange"; see Fig. 149) and by the fact that sebaceous material can be squeezed out if there is an opening. Dermoid cysts are congenital, and are generally first noticed in the young; their lining is composed of true epithelium; they are usually deep seated and attached to the pericranium, and they are especially common about the orbits, anterior fontanel and occipital protuberance. Their contents are

similar to that of wens. Fibroma molluscum *is a solid pedunculated tumor* and is nearly always multiple.

Treatment.—"All sebaceous cysts should be removed, for they may become the site of a malignant tumor." (Caylor) When there is infection with abscess formation, the treatment is limited to incision or poulticing. The removal of the sac will usually have to be deferred until the infection has subsided.

The removal of a sebaceous cyst of the scalp is a matter which requires careful surgical technic. The larger the cyst, the more readily and easily it can be removed. The hair should be clipped and the skin shaved for at least 1 inch around the margins of the cyst. The skin area should then be carefully *painted with full strength tincture of iodine or mercurochrome-acetone* solution. The hair will be compressed and held in place by a snug bandage or towel and the field of operation surrounded by sterile gauze or towel (Fig. 135). Every effort should be made to keep the blood out of the hair. The lines of incision over the convexity of the wen will then be infiltrated with 0.5 or 1 per cent novocain. This line of infiltration should extend ¼ to ½ inch beyond the wen, above and below. The deeper portions of skin underlying the wen then should be infiltrated with hypodermic injections (Fig. 136). The incision is made over the convexity of the wen with the excision of an elliptical portion of the skin lying on the convexity itself (Fig. 137). This is *done to include the possible sinus or plugged sebaceous duct and also to* remove the redundant skin so as to facilitate approximation of the skin edges after the removal of the cyst. It is preferable to leave the elliptical piece of skin *attached* to the underlying cyst, so that this piece of skin and the cyst are removed in one piece. After the skin has carefully been cut through with a sharp scalpel, the edges of the wound are divulsed by spreading the points of the scissors or fine hemostat and, if possible, the sac exposed and identified. A cleavage plane will be found between the sac wall and the underlying tissues, and by further divulsion by means of the scissors, the sac will be separated from its bed. Occasionally, sharp dissection will be preferable. *It is desirable to remove this cyst without rupturing its wall and* spilling the caseous contents, which not infrequently contain micro-organisms. Unfortunately, the cyst will sometimes be cut into in efforts to remove it and the contents will be spilled into the wound. If this occurs the caseous material had best be wiped away as well as possible and the cyst wall, which is often very tough, will be grasped by a mosquito forceps. By traction upon this forceps and further dissection with the scissors, the sac will be removed (Fig. 138). *If by any chance a small part of sac wall is left behind, its epithelial* lining should be cauterized with carbolic acid or other cauterizing agent so as to destroy it. If the sac contents have been spilled in the removal, it will be well to cleanse the wound with soap and water before closure. The skin is then coapted with two or three nonabsorbable sutures and a firm dressing applied. If the wound has been cauterized or if there is any reason to believe that infection is present, it will be wise to put in a small drain for twenty-four hours. On the scalp this dressing is best held in place by a circular bandage about the skull. If a strenuous objection is raised to a head bandage, the next best thing is a small circular gauze dressing, which may be fastened to the shaved skin by liquid adhesive, collodion or, less desirably, adhesive plaster. It is best to dress the wound twenty-four hours after the operation, taking care to remove the gauze lengthwise of the wound. The stitches will

be removed on the fourth to sixth day unless redness, discharge and pain indicate inflammation, in which event they should be removed earlier.[5]

Epidermoid Cyst (Acquired or Implantation Skin Cyst).—An epidermoid cyst is a cavity lined with epithelium which is caused by the traumatic implantation of bits of epithelium in the subcutaneous tissues or by cell rests. There they proliferate and form a cyst wall (Fig. 139). Wien and Caro,[6] who carefully reviewed this subject, say that "such cysts occur most often

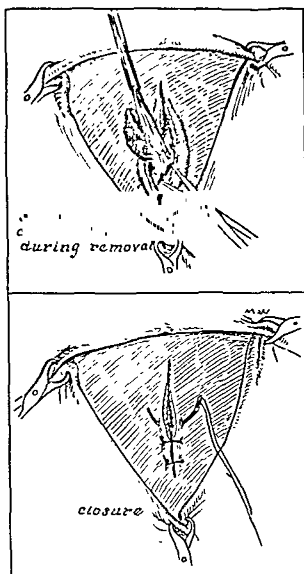


Fig. 138.—Procedure in case the wen is inadvertently ruptured in the process of removal. Below is shown the closure of the skin.

on exposed sites, such as the fingers and palms, and are especially prevalent in those occupations which predispose to injury." They may even occur in bone.[7]

The cyst may become apparent only at a considerable interval after the accident; in 1 case some ten or fifteen years.[8] Recently I saw a patient with an epidermoid cyst in whom injury occurred twenty years previously. Burrows[9] reported a case in which operation occurred twenty-five years after the accident. The removal is effected in the same manner as that of the sebaceous cyst.

Dermoid Cyst.—Dermoid cysts are congenital abnormalities and may be classified into two types. The *teratoma type of dermoid cyst* is of complex structure and arises from the embryonic germinal epithelium. It is usually found in the ovary or testis and may contain skin, hair or teeth. This type of neoplasm usually presents a major surgical problem. *Congenital inclusion dermoid cysts* develop from inclusions of displaced dermal cells along the lines of embryonic fusion, such as the mid-central and mid-dorsal lines and the branchial clefts.[10] They are lined with squamous epithelium that resembles skin and contains a caseous material which is often filled with hair. In many cases the cyst has a sinus leading to the skin. New and Erich studied 1495 dermoid cysts at the Mayo Clinic. Those in the postanal region, includ-

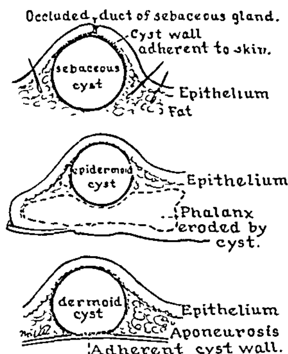


Fig. 139.—Diagram indicating the chief differences between sebaceous cyst, epidermoid cyst and dermoid cyst. The sebaceous cyst is generally attached to the skin at the site of the occluded duct of the sebaceous gland. The epidermoid cyst does not have this attachment, is lined by epithelium, does not contain hair and may erode adjacent bone. The dermoid cyst is often adherent to the aponeurosis and may contain hair or other epithelial structures.

ing pilonidal cysts, made up 44.4 per cent of the total; 42.1 per cent were found in the ovaries. "Excluding patients who had cysts involving the brain and meninges, 103, or 6.9 per cent, of the patients had cysts that occurred in the regions about the head and neck." (New and Erich) The distribution of these 103 cases may be seen in figure 140. The ages varied from 14 months to 72 years, but 60 per cent of the patients were between 15 and 35 years of age; 37.2 per cent of the dermoids had been present since birth, and 62.7 per cent were observed by the fifth year. A dermoid cyst is usually covered with normal, freely movable skin, whereas a sebaceous cyst always is attached to the skin at one point. A dermoid cyst is fixed to the deep structures, while a sebaceous cyst is freely movable on the deep structures.

Dermoid cysts are treated by excision. Some of them have extensive, deep

attachments making removal difficult, and sharp dissection is necessary. Some produce depressions of the underlying bone. Dermoids of the brow are approached through the eyebrow after the hair has been shaved. It may be necessary to open the dermoid to facilitate its total excision. When it is found to be impossible to remove the entire cyst, the lining membrane of the part left behind should be cauterized with carbolic acid. General anesthesia is usually best.

Mucous Cyst (*Mucocele*).—These small cysts, rarely larger than a pea, develop on the mucous membrane of the mouth or lips. They contain a glairy mucous fluid; on the thin overlying wall is a thin layer of mucous membrane. They occur more commonly in children. They can readily be cured with or without surface anesthesia by simple excision of the overlying wall of the cyst with a small, sharp scissors and tissue forceps. After excision of the roof of the cyst, occasionally it is useful to suture the mucosa of the lip to the epithelium of the cyst. These cysts will not recur if all of the overlying wall is removed.

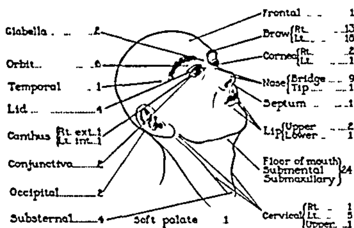


Fig. 140.—Situation of dermoid cyst of the head and neck in a series of 103 cases studied at the *Mayo Clinic* by New and Erich. (New, G. B, and Erich, J. B: Surg., Gynec. & Obst. 65: 48, 1937.)

Ranula. (See Dermoid Cyst.)—Fitzwilliams[11] has made an extensive study of the subject of ranula. He says: "Ranula is a loose term inherited from bygone days and used widely over the world, but it is a term in medicine which cannot be defined and has no scientific meaning. It has been applied to all cystic swellings of the floor of the mouth whatever their form or origin. Dermoid swellings, swellings in connection with calculi of the salivary glands, acute swellings, traumatic swellings, parasitic swellings, swellings below the jaw, and even below the hyoid bone in connection with the thyroid gland, have all been included under the term ranula. . . . There is no one and only cause of these swellings." Ranulae have originated in the mucous glands, the sublingual gland, Blandin's gland and even the submaxillary gland. Fitzwilliams defines as "traumatic ranula" a swelling following the blocking of Wharton's duct as the result of traumatism or by a membrane. Some of the ranulae may be very large and show a propensity to burrow, the extension going through the mylohyoid muscle to below the chin and up into the cheek and neck (Figs. 141, 142).

Treatment.—The best treatment for ranula is excision if this is feasible.

It should be dissected out like any other cyst. In some cases, if this is not feasible, a large portion of the anterior wall should be removed. The edges of the mucous membrane of the cyst will unite with the edges of the mucous membrane of the mouth. In extensive cysts healing is hastened by suppuration

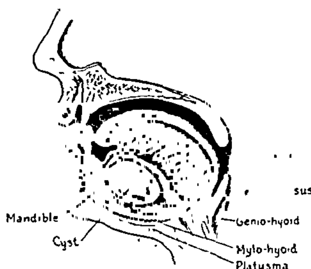


Fig. 141.—Sublingual type of cyst occuring above the geniohyoid muscle. (Eliason, E. L.: Therap. Gaz., April 15, 1926.)

or inflammation or by swabbing the interior with pure carbolic or zinc chloride, 40 grains to the ounce (Fitzwilliams).

Keloid.—A keloid is a fibroma or connective tissue growth in the corium or true skin. It is a hard, fibrous and vascular growth generally arising in

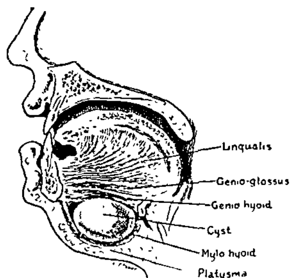


Fig. 142.—Submental type of cyst. Note the geniohyoid muscle above and the mylohyoid muscle below. (Eliason, E. L.: Therap. Gaz., April 15, 1926.)

scar tissue. It is said to attack the mucous membranes but rarely. A special predisposition to keloid formation is present in certain individuals, and it is thought possible that this is hereditary. The colored race and those afflicted with tuberculosis of the lymph nodes are more prone to keloid (Fig. 143).

While it may occur after any injury, it is more likely to occur following burns. The keloid may develop over many years and may subside spontaneously. The cause of keloid is not definitely known. Crocker[12] believes the microbic origin to be very plausible because of the fact that lesions following suppuration are particularly likely to be followed by keloid and that when the process is once started in a scar, old ones, long quiescent, become keloidal. The pathologic picture is given by Fordyce[13] as follows: "The growth is situated in the central and lower portions of the cutis. It begins in the walls of the larger vessels and, when fully developed, is composed of dense collagenous bundles, which are arranged for the most part parallel with the long axis of the tumor, ultimately compressing all the structure in their vicinity. According to Warren, the vessels are affected some distance from the keloid growth." Unfortunately the growth is but little influenced by treatment. Fordyce says that sarcomas have been noticed after keloidal growths. Operation is rarely successful, and recurrence seems to be the rule. Passot[14] advises surgical excision of the keloid followed *immediately* by irradiation



Fig. 143.—Keloid. (Surgical Dispensary, Northwestern University Medical School. Courtesy of Dr. John A. Wolfer.)

with radium. The injection of 10 to 15 minims of 10 per cent solution of thiosinamin into the gluteal muscles every third day has been advocated but has not proved of value. *x*-Ray is to be tried. According to Codman,[15] a few exposures will show improvement if any is to be expected. DaCosta had seen 2 cases cured by *x*-ray. Grier[16] has obtained uniformly satisfactory results in the treatment of keloids with unfiltered roentgen rays. This writer says that the amount of radiation applied at each treatment should not exceed 90 per cent of an erythema dose. Six or eight weeks should elapse between treatments. I have seen excellent results from the *x*-ray treatment of keloids by dermatologists.

Nason,[17] from an experience with 51 keloids, advises: "1. Sharp *knife excision*. It was often necessary to change the direction of the skin tension by the use of Z-shaped incisions, closure of the incised area without tension by means of V-shaped incisions parallel to the long scar of the keloid, or even skin grafting. 2. Sharp cutting, the use of small suture needles, and fine dermal plastic sutures. 3. Accurate skin-edge approximation and early removal of sutures (in from twenty-four to forty-eight hours). 4. Pressure dressings (some keloids can be removed without resorting to surgery). 5. Small doses of roentgen rays from three to five days following operation." *x*-Ray before excision has been advised.[18]

When keloids are subjected to vigorous treatment with radium, remarkable results have been obtained, but it is often necessary to produce a definite burn of the skin if the scar tissue is very thick.[19] According to Fordyce, "Mincing up the tissue by linear incisions to divide the vessels as thoroughly as possible has been followed by improvement and even disappearance." Northrop[20] has removed a number of keloids with the high frequency d'Arsonval current, with no recurrence in any case. The electrothermic coagulation was carried out with an ordinary large-sized sewing needle. MacKee and Eller[21] report the rapid cure of a large keloid by the combined use of the endotherm knife and small doses of *x*-rays. Sheehan[22] states that drainage of the substance of keloidal scars by hydroscopic suture threads is followed by blanching, subsidence and pliability of scar, whose subsequent excision is achieved either without recurrence or, if there is partial recurrence, the new keloid yields to the same treatment.

Painful Scars.—Painful scars have been studied by Kredel,[23] who concludes: "1. Painful and tender scars should be examined for local points of hypersensitiveness. 2. Simple excision of these sensitive spots will relieve the symptoms without removal of the entire scar. 3. Neuroma formation of tiny cutaneous nerves is the most important factor in the production of painful cutaneous scars of long duration. 4. Inflammatory changes may be the cause of pain in recently healed scars. 5. Prolonged healing with subsequent excessive scar tissue about regenerating nerves is apparently conducive to the production of painful neuromas. 6. Demonstration of minute cutaneous neuromas may require the use of special histologic methods for the impregnation of nerve fibers."

Parotid Cysts.—Retention cysts may form anywhere in the parotid gland and should be removed as completely as possible. Because of the tendency to accumulation of the parotid secretion, these wounds should be drained until the secretion gradually ceases, although this may take a number of weeks. Small parotid cysts may form in the healing wounds which have involved the parotid gland. When the epithelium closes over and the cyst begins to form, the latter should be punctured and the secretion allowed to escape. This process may have to be repeated, and suppuration will accelerate the closure.

Cunningham[24] says that "certain solitary and multiple cysts develop in the parotid gland that are of branchiogenic origin. The differential diagnosis may be made from a histologic study of the lining cells. Solitary cells are easily enucleated but the parotid gland which is the seat of multiple cysts, necessitates total or subtotal sialo-adenectomy."

Warts (Cutaneous Warts, Verruca Vulgaris).—The common wart of the skin is a benign epithelial hypertrophy. According to Ewing,[25] "it occurs on exposed regions of the skin, especially on fingers, hands, and face. The duration is very variable, some disappearing after a few weeks, others persisting for years. A tendency to recurrence is often noted. . . . In young subjects very numerous small flat warts may appear on the backs of both hands (verruca plana juvenilis). . . . The structure exhibits an overgrowth of the entire malpighian layer with folds and projections into which extend thin strands of stroma. In some cases there is a considerable increase of blood vessels approaching the type of the papillary nevus, and for these a congenital origin is probable." There are numerous clinical observations

suggesting the contagiousness of warts, but on analysis they can be dismissed as examples of the transfer of peculiar chemical irritants, or exposure to the same irritant, or the actual transfer of proliferating epithelial cells. Payne saw three warts develop under the nail of his thumb which he had used to separate a wart from its base. In many instances warts have developed upon the skin of opposed surfaces. Lanz implanted a series of warts on the back of his gardener's hand by inserting the comminuted fragments under the epidermis. From 74 inoculations from warts in 4 adults, Jadassohn secured in two to six months 33 warts.

Urban Maes[26] says: "No variety of malignancy is more easily prevented than the type which has its origin in warts and moles." He recommends their excision by electrosurgical means. Excision of warts occasionally is done, but it is often unsatisfactory because of the incidence of recurrence, the trouble incident to infiltration, excision and placement of stitches and the resultant scar. Repeated applications of glacial acetic acid or nitric acid will sometimes cure a wart, but it requires extreme care that the surrounding skin not be injured. An excellent method of curing warts is by a fine-pointed electric cautery.

Fox[27] describes his method of treating warts as follows: "In treating common warts it should not be forgotten that they eventually disappear spontaneously. They have been known to disappear apparently from the mental effect of suggestion. At any rate, their duration is extremely variable and capricious. It is therefore proper to avoid scarring as far as possible in their removal, especially as the majority occur on exposed parts of the body. Massive doses of roentgen rays or radium, with close screening of the surrounding skin, will cure a majority of common warts. This method of treatment, if successful, is ideal, as it is painless, causes no scarring, and affords no opportunity for infection. In a few cases of multiple warts on the back of the hands and fingers, I have seen the lesions disappear rapidly after a single dose of 1 'skin unit' roentgen rays, applied without screening the individual lesions. When irradiation fails I prefer to use electrodesiccation (monopolar Oudin current). With this method care must be taken to use a small spark which will not extend beyond the lesion to be treated. Local anesthesia may be used, especially for warts affecting the nail folds, where this method of treatment is decidedly painful. Great care must be used not to overtreat an anesthetized lesion and produce unwarranted scars. Caustic potash is a favorite remedy of some of my colleagues, the surrounding skin being protected with vaselin. I have not been successful with carbon dioxide snow, though freezing by liquid air, which is now easily obtainable, is highly recommended by Irvine. The latter uses this remedy intermittently for three minutes with success. Salicylic acid has long been used for warts, though my experience with this keratolytic agent has not been very satisfactory. I would certainly never recommend nitric acid, on account of its well-known tendency to produce keloidal scars."

Verruca treated by radium with proper protection of the surrounding skin will often disappear in two or three weeks after a single application.

Lurie[28] has cured various kinds of warts in different situations on the body by intramuscular injections of bismuth salicylate. Lumsford *et al.*[29] treated 61 patients with warts with bismuth injections. In 14 cases treatment was discontinued because of illness, local pain, interference with work and lack of cooperation; of the remaining 47 patients, 39 were [illegible] ions [illegible] lults [illegible] 16 [illegible] 7.5 [illegible] given in those cases in which treatment failed, the greatest number being 14 Two adult patients were cured after 1 injection

Shellow[30] employed an aqueous 1.5 per cent solution of bismuth sodium tartrate in the treatment of 97 lesions of various types of verruca occurring in 73 patients: "The skin about the lesion is prepared by washing with soap and water; then iodine and alcohol are applied. A fine hypodermic needle is used to pierce the skin just outside the zone of hyperkeratosis and directed downward and inward toward the base of the verruca at the most active point, the end of the needle remaining just above the corium. From ½ to 2 minims (0 03 to 0.14 cc) of the bismuth sodium tartrate solution is injected according to the size of the lesion. In from one to three days after the injection a dark hemorrhagic

area appears, visible through the keratotic surface. This denotes that the drug has taken effect. In the markedly keratotic hard type of ordinary verruca vulgaris this phenomenon may not always be seen. In most cases, from one to three days after the first injection there has been either a complete cessation or a marked diminution of pain. The peripheral redness that so often accompanies the painful verruca disappears in from two to seven days. All papillomatous lesions flatten out decidedly after the first injection, and in the plantar or palmar types the surface becomes smoother. If within seven to fourteen days following the appearance of the hemorrhagic center the top of the verruca has not come off or the central portion has not fallen out, the keratotic tissue may be removed to determine whether any activity is still present. In most instances, after a lapse of from fourteen to seventeen days following the initial injection the removal of this hemorrhagic keratotic center reveals an underlying normal appearing epidermis. If after two weeks of further observation an active verrucous tissue is seen, the lesion may be reinjected. Of the 97 lesions, most of them having been treated previously by other measures, 89 were cured, 5 improved and 3 showed no improvement. Sixty-seven lesions were of the painful palmar or plantar variety, and 18 were of the verruca vulgaris type occurring on the dorsum of the hands or feet."[30a]

Hutton[31] has introduced a new method for the treatment of warts, which consists of the injection of a small amount of some sclerosing agent into the base of the wart. The injection is made with a tuberculin syringe and a fine gauge needle and is accompanied by a surprisingly small amount of pain. After a few days the wart becomes dry and hard, very much like a callus, and after ten days, two weeks or longer, depending on the size of the wart and the thickness of the surrounding skin, the wart comes off or can be trimmed off, leaving a practically normal skin underneath. The following solutions have been used: quinine and urethrane, 50 per cent invert sugar, equal parts of 50 per cent dextrose and 30 per cent sodium chloride, sodium morrhuate, and potassium oleate. The heavier solutions have a distinct advantage in that they remain localized at the point of injection with less infiltration of surrounding tissue and therefore cause less pain. This increased localization seems also to increase the chance of curing the wart. The sclerosing solution should be injected into the wart rather than into the corium or the subcutaneous tissues underneath the wart. This aids greatly in keeping the injected solution localized by preventing infiltration into the surrounding tissue and minimizing not only the pain but also the resulting reaction within the tissues produced by the foreign substance.

Moles.—The pigmented mole or *nevus* occurs chiefly on the face, neck or back. It may even appear on the sole of the foot, and in this and other exposed positions is more liable to malignant change.[32] The *nevus spilus* is a minute pigmented spot; the *nevus verrucosus* is a soft, flat elevation, which often grows to a warty excrescence; *nevus pilosus* includes hair, and the *nevus papillaris* is a papillary tumor. The source of these tumors is the chromophore, a specific mesoblastic cell, and when the moles undergo malignant change to melanomas, it is often difficult to know whether or not to identify the tumor with sarcoma or with carcinoma. Ewing says: "The natural history of the vast majority of pigmented nevi includes a long period of slow growth, a stage of inertia, followed by process of regression. A congenital disturbance of the structure of the derma must be assumed for all cases, and some moles are visible at birth. Many more appear in early life, and, according to Unna, these always show evidences of progressive growth. [Masson[33] believes that pigmented moles are formed essentially by abnormal proliferation of the ends of the tactile nerves; that nevi are neuromata of tactile nerves and, therefore, not derived from connective tissue at all, as has been supposed by some.] Having reached the limit of growth, which is commonly restricted to small innocuous tumors, they tend to undergo fibrosis and atrophy. Some become hard, flat, and circumscribed (fibromatous degeneration); others become pedunculated, fissured, or extruded (mollus-

cold degeneration). Repeated traumata often causes a limited overgrowth. Malignant melanoma develops *in a small proportion of cases, usually after* trauma or incomplete extirpation. . . . A slight enlargement or increase of pigmentation of the tumor may be the first sign of malignant change which may be checked by wide extirpation. Following operation or without, there may be rapid local growth or extension, but some cases remain localized with repeated extensions for many years." Maes[34] says: "The type of mole which originates in hypertrophy of the capillary layer of the skin tends to become carcinomatous, but excision, even when malignant changes have occurred, is frequently curative. On the other hand, the type of pigmented mole which exhibits enlarged and proliferating blood vessels can develop not only this variety of malignancy but also sarcomatous changes of a peculiarly uncontrollable and rapidly fatal character. The disease exhibits widespread metastases and multiple recurrences and surgery is not only futile but actually seems to hasten the end." He advised the electrosurgical excision of such lesions while they are still innocent as a prophylactic measure.

On the other hand, Fox[35] says: "I do not believe that moles in general are a great source of danger, and they should not be removed in a wholesale manner to avoid the possibility of later malignancy. There are two exceptions to this rule: When a pigmented nevus is in a situation where it is exposed to constant trauma, as on the bearded region in men, it should be removed. The same applies to a pigmented mole which is definitely increasing in size. In general the darkly pigmented moles, especially when covered by hair, may be safely allowed to remain. There is a type which should be radically destroyed or at least kept under careful observation. This is the bluish or slate-colored, smooth mole which is not appreciably elevated. Such a lesion, if irritated by constant trauma or by improper treatment, may be the source of nevocarcinoma, one of the most rapidly fatal types of malignancy." (See Melanoma.)

"For the treatment of flat pigmented moles, it is proper to use electrolysis, electrodesiccation, the actual cautery or carbon dioxide snow, with or without local anesthesia. For very small pigmented nevi I have found the cryocautery of Loftat-Jacob convenient. This apparatus has various sized applicators by which the refrigeration can be confined to the desired area, whereas with a crayon of carbon dioxide snow, pressure is likely to allow the snow to spread beyond the border of the lesion. In small pigmented and hairy moles, it is advisable to remove the hairs first by electrolysis, before using one of the above-mentioned destructive methods. Large hairy moles are best treated by refrigeration or electrodesiccation. For the ordinary circumscribed elevated moles, whether pigmented or nonpigmented, I almost invariably use the electric cautery, being careful not to cause enough destruction to result in a depressed scar."

Most moles are small (0.5 cm.) but they may be much larger. Bland-Sutton[36] says that as many as 50 may be present upon an individual. The usual color is brown, and they may contain an abundant crop of hairs. Moles are removed because they are unsightly and also because of their occasional transformation into malignant growths. Moles which are subjected to irritation or which are enlarging should be removed at once. Dr. Bloodgood, of Johns Hopkins, was particularly impressed with the potential

peril of moles which were subjected to irritation of men's stiff collars. Brown moles may be surgically excised. Ordinary moles may be removed with trichloracetic acid.[37] (See Melanoma.)

Electrosurgical excision is a satisfactory method of removing moles. The mole and at least ⅛ inch of [illegible]
into the mole or tr[illegible]
be well away from [illegible]
by the application of solid carbonic acid for thirty seconds." Salomon[39] says that the best treatment of small moles is by radium irradiation but that ideal results are rare. The needle-point Paquelin cautery with deep punctures or the roentgen ray are also used. Evans and Leucutia[40] say: "It has long been observed that a pigmented mole, when subjected to chronic irritation or repeated trauma, becomes transformed into a malignant melanoma with a rapidly fatal outcome." They consider excision of a pigmented mole a very dangerous procedure and treat all pigmented moles and melanomas by x-ray.

Melanoma.—According to Lee,[41] the term melanoma is properly used for all pigmented tumors, either benign or malignant, arising from pigment-forming tissue such as the skin, mucous membranes of the mouth and rectum, choroid, and leptomeninges. Adair[42] uses the word melanoma for all malignant tumors derived from melanin-producing cells only. For the precursory lesions which may change to melanomas he uses the term pigmented nevi. Malignant melanomas of the skin may appear in any part of the body surface (Fig. 144). Webster and his colleagues[43] found that 24 per cent of malignant melanomas or the moles which preceded them "were known to have received improper, inadequate treatment by a physician." Death occurred in 25 of the 39 cases in which there had been traumatization by a physician. Lee says:

"A benign melanoma, such as the ordinary pigmented mole, should be excised promptly whenever it is situated in an area where it is subject to trauma and irritation. Excision is a simple matter, but it may not be amiss to stress a few points in the technic. In the first place, all efforts should be directed to avoiding any undue manipulation of the tumor and its surrounding skin for fear of forcing some of the tumor cells into channels beyond the field of operation, for trauma and incomplete excision are the commonest causes of malignant change. *Accordingly, the iodine and alcohol should be applied gently, and the needle* for administering the local anesthesia should be inserted well away from the tumor. It is advisable to insert two sutures at a good distance from the tumor, and to use only these threads, and not forceps, in the manipulation of the tissue to be excised. A common mistake is failure to excise the mole widely enough. The danger in this procedure is that only too frequently some tumor cells are situated in the tissue adjacent to the tumor mass, and it is the stimulation and irritation of these accessory cells that is chiefly responsible for recurrences. In addition, the excision must be carried deeply, preferably to the fascia, because the aberrant tumor cells are found deeper in the subcutaneous tissue."

The finding of hair in the mole rather favors the prognosis. "Trauma, more often than incomplete removal, has been primarily responsible for malignant changes in benign pigmented moles." (Lee) Early signs of malignant change, according to Lee, are "(1) a sudden increase in size, chiefly in elevation rather than in lateral spread; (2) an increase in pigmentation and depth of color, particularly if the color has taken a bluish cast; (3) the development of very small, pigmented, pin-point areas in the skin immediately adjacent to the tumor; (4) a tendency for the pigmented area to bleed; (5) inflammation, especially ulcerative, of the tumor." Lee cites the case of a 40 year old woman who had had a pigmented mole behind her right ear all her life. This mole was caught in a comb by her hairdresser and was excised by her physician. The cancer had already spread to the lymph glands of the neck, in spite of several courses of deep x-ray therapy, and the patient died twenty-one months after the first operation.

Mintzer[44] reports a fatal case of melanoma of the scalp which illustrates how a benign pigmented mole that has been subjected to repeated trauma or chronic irritation may

become transformed into a malignant melanoma. The lesion diagnosed clinically as "sebaceous cyst" and removed in 1928 was a fully developed melanoma, and the failure on the part of the surgeon to have the specimen examined was inexcusable. Recurrence was noted six months later, and death ensued a year after the recurrence appeared. The first lesion was apparently localized, and the dissemination followed the second operation, in spite of roentgen treatment. In all probability, at the time roentgen therapy was given to the metastases in the cervical glands, there were metastases in the retroperitoneal glands and in the liver.

De Cholnoky[45] has studied 117 cases of malignant melanoma and he believes that lack of information concerning the extremely malignant lesions that may arise from moles following trauma or chronic irritation is responsible for the patients' long delay in seeking

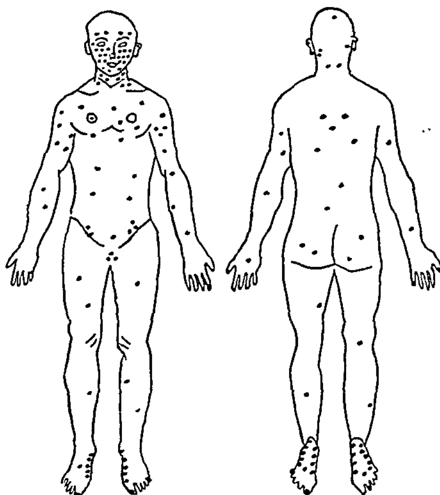


Fig. 144.—Distribution of 162 cases of malignant melanoma of the skin recorded in the Laboratory of Surgical Pathology, Columbia University. (Webster, J. P.; Stevenson, T. W., and Stout, A. P.: S. Clin. North America 24: 319, 1944.)

treatment. The results obtained by surgery are encouraging, but improper treatment or irritation of pigmented lesions must be prevented. Collaboration between the public, practitioners and surgeons is desirable for eliminating those pigmented areas which may undergo malignant degeneration. Beauty parlors, chiropodists and the like need to be warned about the possible consequences of insufficient treatment of the dark pigmented moles. Darkly pigmented ... which are subjected to irritation should be ...
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of wide local excision including surrounding subcutaneous fat tissue and underlying fascia, followed by regional lymph node dissection. Removal *of the lymphatic vessels in the subcutaneous* fat tissue around the lesion and between the lesion and the regional lymph nodes may be desirable in irritated lesions. Amputation of the fingers, toes and foot is advocated for anatomic reasons. In 42.3 per cent of his cases there was a five year arrest and in 19.2 per cent a ten year arrest.

Webster et al.[46] believe that "radical surgical excision offers the best therapy of these lesions." This method permits microscopic study and gives an indication as to the need of subsequent radical excision of regional lymph nodes. If the surgeon is certain of the malignancy of the tumor, the regional lymph nodes should be thoroughly excised either at the time of the original operation or as soon after as possible. Pack et al.[47] permit six weeks to elapse after excision of the primary melanoma before elective groin dissection. Lymph nodes are dissected even if the nodes are not palpable. If the primary melanoma is near the nodes, both may be removed in one block.

Lee says: "The only way to achieve better results is to urge physicians to recommend prophylactic excision of all pigmented areas that are exposed to



Fig. 145.—Hemangioma of the face. (Children's Memorial Hospital, Chicago, Courtesy of Dr. Edward A. Oliver.)

trauma or irritation, because once a benign melanoma has become malignant, all measures to preserve life are usually too late."[48]

Angioma (Hemangioma).—An angioma is a tumor made up of newly formed vessels; if the blood vessels predominate it is called a hemangioma, if the lymph vessels predominate it is a lymphangioma. The *nevus vinosus* (*telangiectasis*) or *port-wine stain* is a new growth of the superficial capillaries, the overlying skin being so thin that the color of the blood is imparted to it. Pressure, particularly with a glass plate, will express the blood and cause the color to disappear. This type is usually congenital and occurs oftenest on the face. In the *plexiform angioma* the small veins and arterioles are involved in addition to the capillaries. The neoplasm occurs in the derma, subcutaneous tissues and fat and forms a definite swelling or tumor. This tumor likewise pales upon pressure. The lesion generally occurs in early infancy and tends to enlarge rapidly. *Cavernous angiomas* (hemangioma cavernosum, "strawberry birthmark") are angiomas in which the vascular channels are widely dilated and the connective tissue septums are thin (Figs. 145–147). "In the skin cavernous angiomata produce *circumscribed or* diffuse, flat or elevated lesions, involving the derma and subcutaneous tissue. If superficial, they are dark red in color. If covered by corrugated

and thickened epidermis, they become warty. Changes in the circulation affect the size and color of the tumors." (Ewing) These lesions may develop from simple angiomas. Hemangioma hypertrophicum (hemangioendotheli-

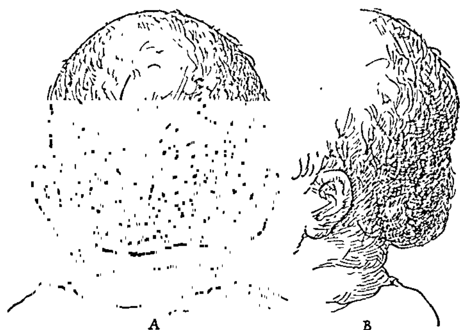


Fig. 146.—Hemangioendothelioma of the scalp. *A*, Anteroposterior view; *B*, lateral view. (Christopher, F.: S. Clin. North America 5: 1085, 1925.)

oma) is a more cellular form of vascular nevus. It is pale blue or gray and is less compressible than the cavernous type. *Malignant metastasizing cavernous angiomas* are sharply to be differentiated from benign growth, and their consideration is foreign to the field of minor surgery.



Fig. 147.—Fibroendothelioma of the chin. *A*, Before excision; *B*, after excision. (Christopher, F.: S Clin. North America 5: 1085, 1925)

For the treatment of hemangioma of the skin, radium therapy is becoming more and more popular. In a series of 94 cases of superficial hemangioma reported by Ward and Covington,[49] radium was the most common form of treatment.

In 40 per cent of the cases the results were good, and in 47 per cent they were satisfactory. In the poor results (13 per cent) were included "(1) all port wine stains (5.3 per cent), which are all radioresistant; (2) most hemangiomas in adults which were radioresistant and which were finally treated with electrosurgery or surgical excision and (3) all cases in which the residuals, such as patches of tumors, telangiectasis, atrophy or loss of hair, were so pronounced that the cosmetic result was considered bad. Solid carbon dioxide was used for very small hemangiomas, residual patches of hemangioma, telangiectasis around the periphery of a lesion previously treated by irradiation, hemangiomas around the eyelids and hemangiomas of the scrotum."

Brown and Byars[50] and Johnson and Light[51] have had excellent results with the implantation of radon seeds in the tumor.[52] Pomeranz and Tunick[53] say: "By injections of radiopaque solutions, such as are commonly employed in intravenous urography, angiomata may be visualized and roentgenographically recorded. Although these chemicals possess sclerosing



Fig. 148.—Injection treatment of "*typical facial hemangioma: A, at age of 8 months* Therapy begun at 10 months. Lesion subjected to five injection treatments during subsequent three months. *B*, appearance of site of lesion at age of 4½ years, three years after treatment." (Kaessler, H. W.: J. A. M. A. 110: 1644, 1938.)

properties, they are best utilized for diagnostic purposes and to determine the extent of sclerosis following the injection of obliterating media. By the use of these chemicals, open operation may be avoided and satisfactory relief obtained."

Kaessler[54] has treated 44 hemangiomas, all with excellent ultimate results, by the injection treatment (Fig. 148). He says:

is placed so that its area of blanching is contiguous with the previous one. Multiple areas are thus injected until the entire lesion has been mottled with areas of blanching. The point chosen for injection often bleeds, but a few minutes pressure with gauze or a drop of collodion will seal the puncture. If the lesion is very irregular in outline or its diameter is greater than the length of the needle chosen, other injection sites may be chosen. A small gauze pad is applied firmly over the entire injected area with adhesive tape. The dressing is removed after from forty-eight to seventy-two hours and the area left exposed. If too much solution has been injected there may be central sloughing, but these areas generally heal uneventfully, although more ultimate scarring results. A month after the initial treatment the lesion should be blanching satisfactorily or there may remain scattered areas of angioma which are beginning to grow afresh. These are then injected individually and after another month has passed one observes that there appears no longer a tendency for growth and that the mass is being replaced by a glistening naturally colored or light brownish epidermis, which in time, according to the area involved and the age of the subject, becomes inconspicuous. It is at times necessary to inject more deeply into the mass if it is quite elevated after the superficial portion has been dealt with. In small hemangiomas of the papillomatous type one may observe complete blanching of the mass with one injection into the base if the injected solution chances to flow into the afferent vessel. From one to six treatments may be necessary."

For the capillary nevus, one or more applications of solid carbon dioxide or electric desiccation is of value. Injection of boiling water has been advocated. When the lesion is small, excision will secure good results. Davis and Wilgis[55] are confident that the treatment of hemangiomas by excision is safer for the patient in the hands of a surgeon with a reasonable amount of skill and experience than is the treatment of these tumors by other methods. For the larger angiomas Clark[56] has secured excellent results by electrodesiccation. Thirty to forty seconds of pressure with solid carbon dioxide will bring about a cure in one or more applications in some cases.

Tavares[57] reports the removal of a pedunculated cavernous hemangioma of the upper lip by excision. This tumor was 8 cm. long and 7 cm. broad. The author[58] excised a hemangioendothelioma of the scalp of a ten week old babe. Drennan and Llinas[59] report a *traumatic aneurysm of the scalp* successfully treated by operation Dowling[60] has treated 5 cases of cavernous nevi by injecting a solution of quinine dihydrochloride and urethane; this was satisfactory. Salomon[38] says that for all deep subcutaneous angiomas and for the larger superficial moles, excision is without doubt the best and most certain method. Because of the danger of recurrence, removal must always be radical.

Lipoma (See section on Lipoma in chapter XIV).—A lipoma is a tumor composed of fat tissues. Lipomas vary greatly in size, some of them weighing many pounds. In the case of internal lipomas, their size may become so great as to cause death by pressure symptoms (Ewing). These tumors are painless and benign. Their occurrence about the head is infrequent. The commonest sites are the back, neck, shoulders, axilla and abdominal wall. The most common type is encapsulated. The diagnosis of lipoma may occasionally offer difficulty because of the resemblance to a sebaceous cyst. An important sign found in lipomas is the orange-peel sign ("signe de peau d'orange"). This is elicited by compressing the tumor between the thumb and forefinger, when it will be seen that the skin overlying the fatty mass is irregularly dimpled by the downward traction of the subcutaneous vertical trabeculae (Fig. 149). Another conception of the orange-peel sign is the appearance of the skin when tightly stretched as over a distended breast. The sense of fluctuation found in a lipoma may be almost identical with that of a fluid cyst. The latter, however, fails to show the orange-peel sign.

The *treatment* of lipomas is excision, which usually may be carried out under local anesthesia. They need be removed only for cosmetic reasons or because of the uncomfortable pressure which they may produce. The encapsulated variety is readily shelled out by blunt dissection after the skin has been incised. The diffuse type will require sharp dissection. Vaughan and

Burnham[61] advise that "after the tumor has been removed, plain gut sutures should be so placed that when tied they will tend to draw together the walls and obliterate the cavity. Several such sutures may be required. If this is done, postoperative subcutaneous hematoma is less liable to occur." For this purpose I prefer silk.

Fat Granuloma.—Abrikossoff[62] says that the fat granulomas following recurrent and intermittent fevers, which were described by the author in 1926, are reactive formations *of a resorptive nature. They may develop in cases of focal necrosis of adipose tissue* as a result of the foreign body reaction of the fat which has been set free in the tissues and has undergone saponification. Since his first report, Abrikossoff has observed fat granulomas resulting from other causes. He distinguishes, according to the etiologic factor, four forms: (1) artificial or injection granulomas resulting from the injection of oily or fatty substances (camphor, paraffin); (2) traumatic fat granulomas; (3) fat granulomas in the vicinity of inflammatory foci due to the destruction of adipose tissue by extension of the inflammatory process, and (4) spontaneous fat granulomas resulting from spontaneous localized necrosis of fatty tissue from ischemia or the influence of toxins on the *fat cells.*

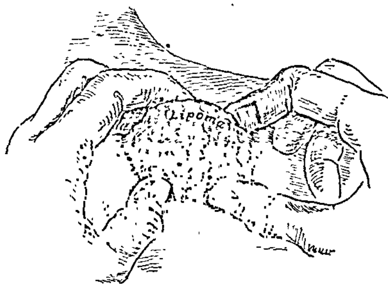


Fig. 149.—Orange-peel sign ("signe de peau d'orange") in the diagnosis of lipoma. Lateral compression of the tumor lifts the surface skin upward, and relatively fixed vertical trabeculae causing multiple dimpling of the skin.

Osteoma (Exostosis).—These benign overgrowths of bone may occur upon the skull or upon the jaw. They are generally removed because of their unsightliness or because they are subject to traumatism. The tissues above the osteoma are readily incised under local anesthesia, but owing to the difficulty of rendering bone insensible by means of local anesthesia, it is advisable to use gas during the removal. A chisel or rongeur will readily remove the neoplasm.

Fibroma.—Fibromas may occur upon the jaw. They generally begin to develop between the ages of 7 and 14 years. These tumors are firm, smooth and circumscribed. They are attached to the bone but not to the overlying soft tissue and are not tender. Some of these fibromas will undergo ossification. Montgomery[63] reported 3 cases of osteofibromas of the jaw and collected reports of 17 cases from the literature. Surgical removal is the only treatment indicated, and recurrence will not take place after thorough operative removal.

Xanthoma.—Xanthomas are small yellow nodules of the skin, particularly

(over 90 per cent) on the eyelids. "The structure of xanthoma is characterized chiefly by the great abundance of lipoid globules in large swollen polyhedral and smaller spindle-shaped cells."[64] These nodules are often extremely disfiguring and may readily be removed by excision under local anesthesia and the subsequent coaptation of the skin with tiny horsehair sutures. The incisions should parallel or correspond to the wrinkles of the eyelid.

Granuloma of the Gum Border.—This tumor may occur from the chronic irritation of a discharging sinus incident to a carious tooth or osteomyelitis of the jaw. Its treatment calls for excision with scissors or for cauterization with a silver nitrate stick.

Epulis.—The term epulis applies to connective tissue tumors which have a circumscribed growth from the alveolar ridge at the gingival margins of the teeth. They generally have a small attachment and spread over the gum surface. According to Ivy,[65] "in their early stages, these growths may be essentially chronically inflammatory in nature, due to irritation of food or tartar beneath the gum margin, ill-fitting crowns and fillings, or carious cavities. Eventually they pass over into the tumor group, and are all essentially of the connective-tissue type. When fully developed, they may be classified into three principal varieties: (*a*) Fibroma; (*b*) fibro-angioma; (*c*) giant-cell tumor." These three types have a microscopical and clinical differentiation. Ivy has given the following directions for the removal of epulis: "Under local anesthesia, an incision in the healthy gum, just outside the limits of the growth, is made down to the bone. Through this incision the tumor is then freed as much as possible from its soft tissue attachments. The tooth most likely to be involved is then extracted, and the tumor may come away, attached to the periodontal membrane near the neck of the tooth. If not, the tooth on the other side of the tumor must be removed. The bony margins of the tooth sockets are trimmed smooth with rongeur forceps. In some cases it is possible to fashion a flap of healthy gum and suture it over the exposed bone surface. If not, the raw bleeding surface can be covered with a small piece of iodoform gauze." Epulis may be treated successfully with radium.[66]

Dentigerous Cyst (Odontocele, Coronodental Cyst).—"A dentigerous cyst, or odontocele, is a benign hollow tumor due to proliferation and degeneration of cells of the enamel organ before eruption of a tooth, which lies partially or completely within the cyst cavity."[67] A fully or partly developed tooth projects into the cavity. Ewing[68] says that the tooth is usually misplaced, lying horizontally, a position which prevents its eruption. Hopewell-Smith[69] says that in examining the unerupted tooth lying in the cyst sac, he found that it possessed no enamel cuticle or Nasmyth's membrane. "From this he argued that the outer layer or cells of the enamel organ, instead of adhering to the enamel of the tooth as Nasmyth's membrane, has separated from it and forms the epithelial lining of the cyst capsule. He accounts for the mucous fluid in the cyst cavity by degeneration of the stellate reticulum." (Ivy) The dentigerous cyst forms in the mandible or superior maxilla and may form a thin projecting portion. The treatment consists in the removal of the cyst and the tooth if it is not possible to make the latter of use. "The overlying gum is dissected back in the form of a flap, some of the thin bone is removed with a knife, scissors, or rongeur forceps, and the cyst capsule is seized and gradually separated from the wall of the bony cavity." (Ivy) In most cases the cavity will have to be packed and allowed to heal from the bottom.[70]

Rhinophyma (Rosacea Hypertrophica).—A rhinophyma is an overgrowth of the nose, particularly the sebaceous glands, their ducts, the blood vessels and the fatty tissues. The tumor is benign but is removed because of cosmetic

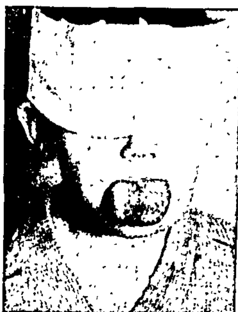


Fig. 150.—Lymphangioma of the tongue, which decreased in size following *x*-ray treatment. (Children's Memorial Hospital, Chicago. Courtesy of Dr. Joseph Brenneman.)

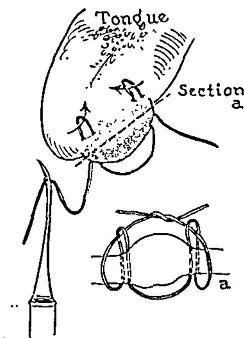


Fig. 151.—Method of removal of a nevus of the tongue by the ligature method. (Redrawn after Wood.)

reasons. The lesion is removed in one or two periods by means of local anesthesia, special care being taken to control hemorrhage.

Tumors of the Tongue.—While it must be remembered that carcinoma is the commonest tumor of the tongue, many benign tumors also occur. Of

these, the papilloma is the commonest. A papilloma is a wartlike tumor which occurs chiefly on the dorsum of the tongue and from birth to old age. It may be single or multiple. While most of them are small, enormous ones have been reported. Fitzwilliams[71] says that the diagnosis is readily made in children and in young persons, it being possible to confuse it only with a papilloma. In older patients, if there is any question as to the nature of the disease, the only sure procedure is to remove the papilloma with a moderate amount of healthy tissue around its base. The tissue is then examined by a pathologist.

Other benign tumors of the tongue include congenital tumors, tumors of the circulatory system (Fig. 150), lipoma, fibroma, keloid, cartilaginous and bony tumors, amyloid tumors, myxoma, rhabdomyoma, endothelioma, cylindroma, neurofibroma and adenoma.[72] Generally these tumors are readily excised. In the case of the larger vascular tumors, the tongue is split and the portion containing the nevus is tied off (Fitzwilliams). Diathermy and electrolysis are useful. Removal by ligature is illustrated in figure 151. Sarcoma of the tongue is rare. A case was reported in a girl of 16 years by Derman.[73]

Leukoplakia is the designation given the white patches on the tongue (or lips or buccal surface of the mouth) due to piling up the superficial layers of epithelium. They are definitely precancerous lesions. Removal of irritation may bring about a cure.[74]

MALIGNANT TUMORS OF THE HEAD

With some reason it has been objected that no malignant tumor may be included in the domain of minor surgery. I am inclined to believe, however, that precancerous lesions and certain circumscribed tumors of low grade malignancy may properly be described here.

Oliver[75] considers senile keratoses, seborrheic keratoses, arsenical keratoses, leukoplakia and chronic radiodermatitis to be precancerous lesions. His description of these lesions and their treatment follows:

"1. Senile keratoses are generally seen in elderly people, in those of blonde or sandy complexion, those that freckle easily, and those whose occupation has necessitated a life outdoors and exposure to the active rays of the sun. They are more commonly seen in men than in women. Their location is generally the face and the backs of the hands. Senile degeneration of the skin may play a part in their development, but more probably exposure to the sun's rays in a skin of low toleration is a better explanation.

"These lesions are pea-sized or larger, dirty gray or brown in color, dry, brittle, and firmly adherent to the skin. They are curetted off with difficulty and when forcibly removed the operation is painful. Unless they are completely destroyed they tend to recur in situ. If allowed to remain they often degenerate into carcinoma of the skin, generally of the squamous cell type. On the back of the hand and on the mucous membrane of the lip they invariably become squamous cell carcinomata.

"*Treatment.*—As soon as such lesions are recognized, they should be destroyed. This can be done with electrodesiccation, with the cautery or they may be excised. Superficial lesions may be frozen with carbon dioxide snow, others may be removed by the application and utilization of the beta and gamma rays of a radium plaque.

"2 Seborrheic Keratoses.—These are commonly known as seborrheic warts. They are relatively common on the skin after the age of fifty. For the most part they are harmless, though occasionally there is a possibility of carcinoma developing. Such a carcinoma is generally of the basal cell type. The commonest locations for such lesions are the sides of the face, ab[illegible]
they occur on [illegible]
brown, dark [illegible]

off the skin, crumble, leaving a raw, slightly verrucous base. Their cause is unknown, but occurring in seborrheic areas, they are probably seborrheic in origin.

"*Treatment.*—Many of these lesions can be left alone safely. If they are annoying to women, because of their appearance, they can be curetted off and the bases cauterized with carbon dioxide snow, the electric cautery, or the entire lesion desiccated.

"3. **Arsenical Keratoses.**—Arsenic should never be given over a long period of time without frequent and prolonged rest periods. Very often the prolonged ingestion of arsenic in the shape of Fowler's or Donovan's solution has produced *numerous keratoses of the* skin. This type of lesion especially affects the palms and soles. The skin is dry and beset with numerous, small punctate keratoses, pinhead to pea size, some superficial but many deep seated. Very often dangerous squamous cell carcinomata develop from such lesions.

"*Treatment.*—Because of the large number of lesions generally present it is difficult *to eradicate them. Large lesions and those that appear* to be degenerating should be removed as soon as possible. This can be done best by surgical means. The skin should be kept soft with frequent greasing with lanolin or cocoa butter.

"4. **Leukoplakia or Leukokeratosis Buccalis.**—This is a very common precancerous condition and at the beginning occasions few, if any, subjective symptoms. Sometimes a feeling of stiffness in the mouth or irritation from hot or spicy foods first calls attention to its presence. On examining the mouth the lesions are seen on the buccal mucosa in a line opposing the junction of the upper and lower teeth. One also may see it on the dorsum and sides of the tongue and even on the gums. It must not be confused with lesions of lichen planus or lupus erythematosus. In most cases there are evidences of these diseases on the skin. The lesions themselves appear as white spots, streaks or plaques of irregular size and shape; often their surface is rough and verrucous, but in some cases it is smooth and velvety. Their color is a whitish gray, often likened to a mucous membrane that has been penciled with silver nitrate.

"*The more pronounced lesions often feel stiff, and rough to the palpating finger,* are generally covered with a tough adherent pellicle, removable with difficulty, and unless fissures have developed occasion little pain. These lesions develop slowly and may cause little inconvenience for years, but when fissures develop they are deep ones extending into the derma and causing a great deal of distress. Later peeling and exfoliation of the surface occurs and carcinoma develops.

"The general belief among competent dermatologists is that many factors enter into the production of leukoplakia. It may be caused by syphilis, prolonged local irritation, the use of tobacco, faulty occlusion, ill-fitting dentures, pyorrhea, jagged teeth, and poor mouth hygiene. McCarthy believes the use of tobacco is the most important factor in the production of leukoplakia, but faulty occlusion and consequent bruising of the mucosa is another important factor.

"*Treatment.*—The treatment of leukoplakia depends to a considerable extent on the type of condition that is present. Generally, treatment is unsatisfactory. First of all, tobacco, highly seasoned foods, and spicy foods should be interdicted. Ill-fitting dentures should be discarded, faulty occlusion corrected, jagged teeth smoothed down, and care and attention given to oral hygiene. If the patches are smooth, not fissured, nor showing any signs of irritation, they should be left alone but carefully inspected every three to six months. The vast majority of leukoplakia conditions require no treatment. If fissures, ulcerations or vegetations appear, then immediate steps should be taken to destroy the patch. This is done best with electro surgery though in small areas the cautery works nicely. If extensive patches that show signs of becoming malignant are present, they should be excised surgically. It is believed that the use of radium and x-rays has no place in the treatment of this condition, and the use locally of irritating or caustic remedies is [illegible]

and if positive, anti-

ave little effect on the

ious types of lesions,

the sequelae of over treatment. While the percentage of malignant change may not be high, cancer develops often enough to make this kind of tissue dangerous. When degeneration does occur it is generally of the squamous cell type. The lesions in x-ray skin that demand energetic and immediate treatment are ulcers and keratoses Keratoses should be destroyed either with electro-desiccation or excised completely. Ulcers should be removed with wide excisions, *including some of the normal* tissue, to be certain that no diseased

tissue has been left. The excised area should then be covered with a skin graft. For areas that show only atrophy and telangiectasis, careful inspection should be made every six months to see that no keratoses or ulcerations have developed."

All small, warty outgrowths, particularly those at the mucocutaneous borders, should be considered as potentially malignant. If they are present in elderly individuals and are subject to more or less continuous irritation, they should be viewed with even more suspicion and should be removed. The removal should be by excision in order that histologic examination may be carried out. Local anesthesia is permissible, but care should be taken to keep well away from the lesion with both the injecting needle and the scalpel. Many workers believe that the best treatment of these lesions is electrocoagulation with surgical diathermy. They contend that this method offers far less likelihood of dissemination of the neoplasm during the process of removal. In a case of the writer's there was considerable hemorrhage following surgical diathermy for an epidermoid carcinoma of the lip. The hemorrhage occurred when the slough separated. It has the disadvantage, furthermore, of preventing histologic examination. The treatment of the more malignant type is a major surgical problem.

Acanthoma is a type of epidermoid carcinoma which is characterized by the presence of adult *squamous cells*, hornification and pearly formation. (Ewing) The tumors are single or may be very numerous. They are found chiefly at the mucocutaneous junctions and on the face, scalp, chest, breast, back of the hands, shins and toes. There are two types of acanthoma, the less malignant and the more malignant. In the less malignant type the lesion appears as a warty outgrowth, movable on the superficial fascia. It is histologically malignant but remains localized for a long time; when it does spread, the direction is laterally. In this early stage, before the skin is fixed and ulcerated, the prognosis after local removal is excellent. The more malignant type of acanthoma is flat, depressed and indurated. It early infiltrates the deeper structures and lymph nodes and tends to assume the structure of a tubular carcinoma. According to Ewing, "acanthoma of the skin is almost exclusively the result of chronic traumatism."

Basal Cell Epithelioma.—The basal cell epithelioma develops chiefly from the basal cells of the malpighian layer of the skin, in distinction to the acanthoma or squamous cell type. There are two main types, viz., the *reticulated epithelioma*, or *rodent ulcer*, and the *adenoid epithelioma*. The rodent ulcer grows very slowly, does not involve the lymph nodes and is rarely fatal (Fig. 152). Incomplete excision is often followed by a more rapid growth. The adenoid epithelioma shows a tendency to reproduce the dermal glands. It is more malignant than the rodent ulcer, and its treatment is a major surgical problem.

Payne[76] says that "cases which we considered to be simple basal cell in type were, in some instances, either primarily squamous-cell or primary basal-cell type which had eventuated into a squamous-cell epithelioma . . . all cases of epidermoid carcinoma irrespective of size, involvement or location should have immediate and complete destruction by endothermic methods and the surrounding structures properly treated with radium or x-rays in order to bring about retrogressive changes in the cells and thus prevent the inherent possibility of recurrence or renewed growth." From this study of selected groups Payne stated that "the mortality in 201 cases treated by radium alone was 8 4 per cent. The mortality in 120 cases treated by endothermy alone was 4.6 per cent. In a series of 75 cases treated by the combination of endothermy and radium there was no mortality."

Schreiner and Wende[77] present the end-results of their treatment in 355 cases of basal cell epithelioma. Their conclusions are as follows: "1. Irradiation (unfiltered *x*-rays, radium), as used in this series, has yielded primary healing in 88 per cent of 340 cases, in 82 per cent of which healing lasted until the time of death, until the patient was lost from observation or for more than five years. 2. The favorable cases, treated by irradiation, yielded primary healing in 92.5 per cent, with permanent healing in 86.5 per cent, on a basis of five years. 3. The far-advanced cases, treated by irradiation, have shown primary healing in 39 per cent of 33 cases, with permanent healing in 11 per cent on the five-year basis. 4. From the analysis of these cases it would seem that the cooperation of physicians and laymen should result in from 95 to 99 per cent of permanent healing. 5. The far-advanced basal-cell epithelioma is the result of no treatment or of inadequate treatment, with few exceptions. 6. This disease is essentially a disease of middle life or of old age and its proper eradication by treatment is the means of sparing untold misery to the patients, as well as to the family or persons in whose care they are entrusted. 7. A plea for early



Fig. 152.—Rodent ulcer (basal cell epithelioma), cured by *x*-ray treatment. (Courtesy of Dr. Edward A. Oliver.)

diagnosis and proper treatment in individual cases is hereby made to physicians at large and to those who are entrusted with the propaganda of enlightening the public."[78]

Chemosurgery for cancer of the skin surface has been studied by Mohs.[79] Of 440 consecutive primary malignant lesions treated, 93.0 per cent were cured. The agent used was "fixative Z-108a," the formula of which is as follows:

Stibnite, 80 mesh sieve	40.0 Gm.
Sanguinaria canadensis	10.0 Gm.
Zinc chloride, saturated solution	34.5 cc.

Carcinoma of the Lip.—While this subject is scarcely in the field of minor surgery, it may be wise to mention it in order to quote Sutton,[80] who says: "The old V-shaped knife incision for removal of carcinoma of the lip is little short of criminal, as is also the indiscriminate use of roentgen rays, often by careless or inexperienced operators." He depends upon radium and electrocautery, alone or combined. Hyndman[81] says, in part, "About 80

per cent of epidermoid carcinomas involving not more than one-half of the lower lip will not be associated with regional metastases. The indiscriminate use of radical surgical intervention and irradiation is neither necessary nor to the best interest of these patients. . . . Since for the great majority of patients having carcinoma of the lower lip radical dissection of the glands will be found not to be indicated, these patients should be spared radical operation. On the other hand, when metastasis is proved or when the primary lesion is histologically highly malignant, complete bilateral dissection of the regional glands followed by irradiation should be done."

Molesworth[82] has treated 50 patients with carcinoma of the lip by *x*-ray with but 2 recurrences. Elliott[83] uses electrocoagulation and irradiation.[84]



Fig. 153.—Squamous cell carcinoma, very malignant. (Courtesy of Dr. Edward A. Oliver.

Mixed Tumors of the Parotid.—In cases of parotid tumor, Trueblood[85] believes that "the entire parotid gland can and should be removed with the tumor it harbors without permanent damage to the facial nerve."[81]

CONGENITAL AND ACQUIRED DEFORMITIES OF THE HEAD

Congenital Deformities

Harelip; Cleft Palate.—Harelip, or the congenital incomplete closure of the upper lip, and cleft palate, the congenital incomplete closure of the palate, are ailments whose difficult treatment should never be undertaken by anyone who is not specially trained in that work. The treatment certainly belongs in the realm of major surgery.

Tongue-Tie.—Tongue-tie, or abnormal shortening of the frenum of the tongue, will result in limitation in the extension of the tongue and often slight impediment to speech. Among 1000 clinic patients with disorders of speech, McEnery and Gaines[86] found only 4 who had seriously shortened frenums. This condition is readily apparent in young infants and is treated by the simple procedure of clipping the frenum. For this purpose the slotted blade of the common grooved director is useful. The blade is so introduced that the frenum passes through the slot (Fig. 154), and the frenum may thus be easily clipped. It may be torn further backward with the finger. Extreme care should be taken not to cut the frenular artery or to cause profuse hemorrhage. If, however, the latter is occasioned, one must be sure to control it before permitting the patient to leave the office. In the after-care, daily dressings should prevent the formation of adhesions. Sometimes vicious scars or abnormal mobility results from this operation.

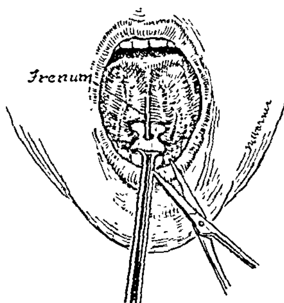


Fig. 154.—Method of clipping the frenum in tongue-tie.

Hypertrophy of the Gums.—In young children the gum or gingiva may become so hypertrophied at certain sites as to cause separation of the teeth. If neglected, this condition will cause a permanent, unsightly separation of the teeth, generally in the midline of the lower teeth. This hypertrophied portion of the gum should be carefully excised.

Deformities of the Ear.—*Auricular Appendages.*—The ear sometimes bears small congenital protuberances at various situations on the auricle. Some of these contain cartilage. They are best treated by excision or, in the case of the smaller ones, by merely snipping them off.

Markedly *protruding ears* may be greatly improved by the excision of a crescentic portion of skin on the posterior side which will tend to draw the auricle more closely to the skull.

Coloboma Lobuli.—This is a congenital fissure of the external lobule of the ear. It may also occur as the result of a traumatism, as in women as the result of wearing heavy earrings. The slit in the ear becomes covered with epithelium and is a permanent deformity unless treated. The edges of the slit,

together with the scar tissue, should be cut away and the cut edges united with very fine sutures.

Enlargement of the Lobule.—This condition is corrected by the excision of a V-shaped wedge, the base of which is at the periphery of the ear.

Macrotia (*Enlargement of the External Ear: Cauliflower Ear*).—This condition may be congenital or the result of repeated trauma, such as that received by wrestlers and prizefighters. The most popular operation for the correction of this defect is Schwartze's, which is described by Vaughan and Burnham[87] as follows: "The operation consists in removing an elliptical segment from the pinna through its entire thickness and a triangular section from the upper portion of the ear, the base of the triangle being formed by the outer margin of the helix and the apex extending to the concha."

Abnormal Prominence of the Ears ("*Lop Ear*").—This condition is usually congenital and generally is a cause of great embarrassment to the patient. The following is the method of Davis and Kitlowski[88] for the correction of this condition:

"We prefer a general anesthetic, usually avertin, 60 to 75 mg. per kilogram, supplemented by nitrous oxide and oxygen. The operation can easily be done under local anesthesia, but it is tedious and we have found that the patient, in the long run, is better off under a general anesthetic. The patient is placed on a brain table with the face down. In this way both ears are fully exposed at the same time in the most favorable operative position, and the clean-up and drape on both sides can be done before the operation is begun. The hair is shaved around the ear for a sufficient distance; the external auditory canal is plugged with cotton wet with alcohol; and this is followed by a thorough clean-up with ether, alcohol and kalmerid.

"The ear is now held in its normal position against the side of the head, and its upper and posterior limits are marked on the scalp with 5 per cent brilliant green in alcohol in order to indicate the general position to be attained by operation. When the ear is in this position, it will be found that the portion of the antihelix which is unfolded will reform itself sufficiently to give the line of required reconstruction, and this line is marked out on the anterior surface of the ear with the brilliant green solution. Then along the full length of this line a series of punctures, five or six or more in number, and about 1 cm. apart are made in the following manner. An hypodermic needle, at least one inch long and about 24-gauge, dipped in brilliant green solution and placed at right angles to the anterior skin surface is thrust completely through the ear from front to back, coming out at a corresponding skin point on the posterior surface. When the needle emerges through the sk
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would be the case if there were dye in the needle or syringe. A green puncture mark shows on the skin of the anterior surface of the ear where the needles enter and similar marks are found on the skin of the posterior surface of the ear where the needles emerge. The

ends are extended and joined is more or less elliptical in shape, will be the skin area to be excised.

"The

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Then, depending
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simple incision through the cartilage is to be made, or whether both incision and excision are used, the selected procedure is carried out with a small sharp blade. We find that the finger in the anterior surface of the ear will give one a guide and will aid in preventing the perforation of the skin on this surface. If an area of cartilage is to be excised, the

incision is made all around it and completely through it, and it is then stripped out with a thin flat elevator.

"It is important to see that the incision or excision of the cartilage extends the full length of the antihelix and that all cartilage spring is divided so that there will be no resist-

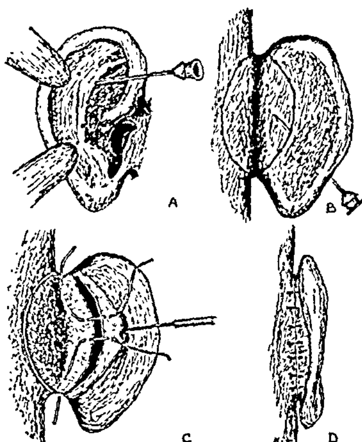


Fig. 155.—Schematic drawings showing the steps in the operation for the replacement [illegible]

ear in this position the undeveloped antihelix will *reform sufficiently to indicate* the line of proposed reconstruction Along this line with an hypodermic needle dipped in the brilliant green solution, punctures are made completely through the ear and about 1 cm. apart. *B*, Shows the puncture marks and the needle emerging on the posterior surface of the ear through one of them. The needle shown in the drawing is comparatively much larger than that actually used, which is 24 gauge and 1 inch long. The points of perforation are connected with a line of brilliant green and while the solution is still damp the ear is pressed against the head and a contact line is made This line is freshened with the green solution and the ends are carried forward and joined, making an elliptical-shaped pattern. The area of skin thus outlined is that which is to be removed. *C*, The skin has been removed. The marks of the perforations in the skin can be seen. The second line of green-stained dots are those left in the cartilage by the needle punctures through the ear. The area from which the cartilage was excised, which conforms to the curve of these perforations, is shown. The cartilage spring has been broken. Two sutures of catgut of the type used to turn in [illegible]

ance or tension when the margins are turned in to form the new antihelix. The new antihelix is formed by turning forward the margins of the cartilage to form a supporting ridge. This is done by passing a catgut suture (No. 0 or No. 1, plain) through the perichondrium on one side beginning about 0.5 cm. from the cartilage margin and coming out close to

the margin. The needle is then carried across the defect and enters the perichondrium a similar distance from the margin and then out about 0.5 cm. from the defect. This suture is of the Lembert type. Four or five of these sutures are placed and then all are drawn up at one time and are tied in order. It will be found that the cartilage edges have been turned forward toward the anterior surface of the ear, replacing the unfolded portion of the antihelix, and that the ear immediately assumes a position which approximates normal. The skin is then closed with on-end mattress sutures of horsehair.

"After the operation is completed, the ears will sometimes appear to be almost too close to the head, but in time the sharp overcorrection of the reconstructed antihelix will relax.

"The dressing of the reconstructed ear is of considerable importance, since immobilization and perfect support of the newly adjusted cartilage are essential for a good result. The sutured line is painted with one-third strength tincture of iodine. A single layer of gauze impregnated with 3 per cent xeroform ointment is laid over the stitch line. Over this is placed a narrow strip of sterile seasponge between the ear and the scalp, and the ear is held close to the head. Then with small bits of seasponge every portion of the anterior part of the ear is carefully and snugly packed, eliminating all dead space and giving absolute support to the readjusted cartilage. After the ear has been completely filled with the sponge bits, a single larger piece of seasponge is placed over the whole and secured by strips of adhesive. Over this is placed a snug bandage, care being taken to avoid pressure sloughs. Unless some untoward symptom presents, the dressing is allowed to remain undisturbed for ten days, at which time the horsehair stitches are removed, and a snug dressing is applied. All dressings are completely removed in another week, and the patient is instructed to hold the ears close to the head at night for about three months by a closely fitting bandage or skull cap."

Thyroglossal Cysts of the Tongue.—Thyroglossal cysts may be found in the tongue. The cysts are found at the foramen cecum or, less frequently, at the base of the tongue above the hyoid bone, but "the vast bulk of them are situated below this level." (Fitzwilliams) These cysts are remnants of the embryonic thyroglossal duct and should be treated by excision. The dissection is difficult and should not be undertaken until the child is 6 or, better, 8 years old. All but a few of the smaller superficial cysts are subjects for major surgical treatment.

Congenital Fissure of the Lower Lip, the Angle of the Mouth or the Outer Canthus of the Eye.—These fissures may be treated by excision with approximation of the skin edges and the consequent obliteration of the defect.

ACQUIRED DEFORMITIES

Scars.—Following burns and infected wounds, unsightly cicatrices may develop in the region of the eyes and mouth.

Grattan[89] defines a scar as "evidence of prior dissolution of tissue as a result of injury, operation, or disease, followed by the process of replacement and repair." Not infrequently scars may be so unsightly as to require some effort at their removal. Various methods for this have been devised, but the "triple tech[illegible]
The three s[illegible]
tion by ac[illegible]
therapy of the new hairline scar to prevent over-repair and to promote absorption; (3) trichloracetic treatment of any elevations in or around the remains of the hair-line scar, to effect leveling and to eliminate "shadowing." For the details of this method, which Grattan has used in more than 1000 cases, the reader is referred to that author's paper.

Depressed Scars.—Simple depressed scars are admirably treated by the method of Blair. The depressed area is scooped out by a curved incision, and the wound thus made is carefully approximated with sutures.

Unstable Scars.—After extensive burns or the loss of tissue by trauma or operation, when the wound has been allowed to heal by the slow process of cicatrization, the wound will often break down after the slightest trauma and will be a source of greatest annoyance to patient and surgeon. For the treatment of these conditions Davis[90] has devised the method of *relaxation incisions.* His technic is as follows: "Preferably the area should be entirely healed before the incisions are made, but in some instances when the healing of the superficial ulcers has been extremely sluggish, I [Davis] have not waited for complete healing, but have operated as soon as the granulations have been brought into a healthy condition. In preparation for operation in the unhealed cases, after the granulations are healthy, the part is put in a

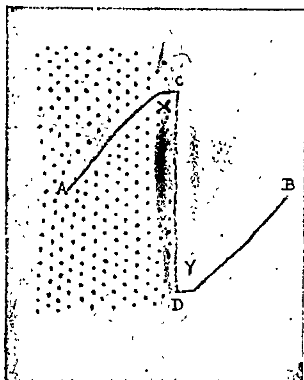


Fig. 156.—Demonstrating the Z-type incision which we have found most generally useful with the transposition of flaps. A piece of chamois skin was placed on a frame and the central portion was stretched snugly between two thumb tacks to represent a scar bridle. Note the "scar bridle" CD which projects quite markedly. Along the center of this bridle is the longest line of the Z; the arms of the Z, DB and AC, are marked out so that the tips of the flaps X and Y will be blunt. A portion of the skin has been dotted in order to show contrast after the flaps are transposed. (Davis, J. S.: Ann. Surg. 94: 871, 1931)

dressing kept wet with normal salt solution for twenty-four hours. The granulations are then painted with tincture of iodine, and the surrounding surface is cleaned with ether and alcohol. In many cases the relaxation incisions can be made after infiltration with a local anesthesia such as Schleich's solution, or 0.5 per cent novocaine. In other instances a general anesthesia is advisable, especially if large immediate Ollier-Thiersch grafts are to be used to cover the defect. On an arm or leg, long incisions should be made parallel with the long axis of the part, down to the deep fascia; or to healthy tissue if the destruction has been deeper than the fascia. Three relaxation incisions are usually sufficient for a limb, and they result in gaping wounds. The immediate spread of each relaxation incision varies with the

tightness of the scar. In some instances it is as much as 6 to 8 cm. at the center of the incision. After the tension has been relieved, the appearance of the scar tissue between the incisions soon changes and, instead of the thin, mottled, glossy look, the tissues seem to thicken and acquire greater stability. The improvement is much more marked after a few days." Davis then grafts the defects caused by the relaxation incisions.

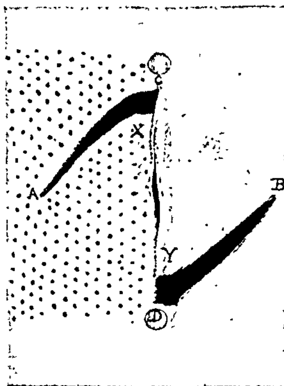


Fig. 157.



Fig. 158.

Fig. 157.—Illustrating the shrinkage of the flaps after the Z-incision has been made. The incision has been made along the Z previously marked out ABCD, and the flaps X and Y lie completely separated and theoretically undercut. Note the gaps along the arms of the Z, which in a real scar are often much more marked, as naturally the scar pull would be greater than that in a piece of chamois skin. (Davis, J. S.: Ann. Surg. 94: 871, 1931.)

Fig. 158.—Illustrating the transposition of the flaps and breaking of the scar pull. Note the position of the flaps after transposition. The flap X made in the dotted portion of the skin being drawn into the defect made by raising the flap Y in the undotted portion and vice versa. The tip of the flap X being sutured to the point B and the tip of the flap Y being [illegible]
hair [illegible]
flap [illegible]
Note the increase in the distance between the thumb tacks as the relaxation obtained by the transposition of the flaps made it necessary to move them outward to the edges of the frame; also that the suture line is the staggered reverse of the original incision. (Davis, J. S.: Ann. Surg. 94: 871, 1931.)

In an important paper Davis[91] has pointed out the value of the relaxation of scar contractures by means of the Z- or reversed Z-type incision, which stresses the use of the scar infiltrated tissues. The method is simple and may best be understood from the accompanying diagram from Davis' article (Figs. 156–158). After years of experience, Davis[92] says: "It is my

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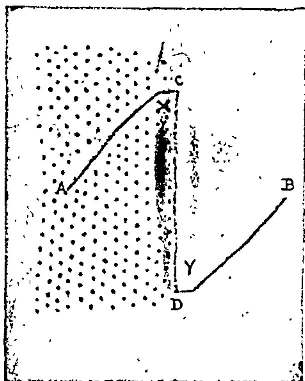


Fig. 156.—Demonstrating the Z-type incision which we have found most generally useful with the transposition of flaps. A piece of chamois skin was placed on a frame and the central portion was stretched snugly between two thumb tacks to represent a scar bridle. Note the "scar bridle" CD which projects quite markedly. Along the center of this bridle is the longest line of the Z; the arms of the Z, DB and AC, are marked out so that the tips of the flaps X and Y will be blunt. A portion of the skin has been dotted in order to show contrast after the flaps are transposed. (Davis, J. S.: Ann. Surg. 94: 871, 1931.)

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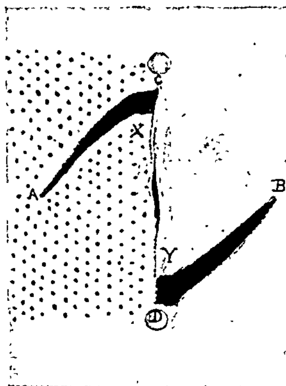


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considered opinion that the Z-incision with the transposition of flaps thus made is the most generally useful procedure for the relief of scar contractures, and for the readjustment of misplaced tissues, in the entire field of plastic surgery."

Contracted Scars.—For the removal of contracted scars it is necessary to excise the entire scar and either close the edges or fill the defect with a skin graft or a pedunculated flap.

Superfluous Hair.—Cosmetically objectionable hairs may be temporarily removed with an epilating wax. Pusey[93] describes a wax which is efficient for epilation and which is as satisfactory as commercial waxes. It is composed of beeswax, 1 part by weight, and finely powdered rosin, 4 parts by weight. The wax is melted over a low fire and, after melting is complete, the powdered rosin is poured in. The heat is continued and the mass stirred gently until entirely melted; this requires from one to two minutes. Pusey continues, "The method of removing hairs with the wax is as follows: A block, or the end of the stick, is melted by heating over a flame until it becomes soft; this can be done with a temperature that will not burn the skin. When softened, the melted wax is rubbed on the skin in the direction of the hair growth. It is well to press it down with the moistened end of the thumb, until one gets a layer about ⅛ inch thick. This is allowed to cool, or is chilled by the application of ice or cool water. After it is cooled, the edge of the wax is picked up with the nail and the wax pulled off with a quick pull in the opposite direction to the growth of the hairs. This is only slightly uncomfortable. If the application has been well made—and it is easy to learn to do this—few hairs will remain on the surface. Those that do remain had best be left for subsequent application, or removal with epilating forceps. The fragments of wax that stick to the skin can be picked off or easily dissolved with carbon tetrachloride."[94]

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CHAPTER XI

INJURIES AND INFECTIONS OF THE NECK

INJURIES

The neck is much less liable to contusions and wounds than are the head and the chest because of its relatively sheltered situation. Contusions at the neck of such severity as to cause considerable subcutaneous hematoma may give rise to alarming symptoms because of pressure on the trachea. Prompt incision and evacuation of the hematoma are indicated.

Fractures of the Trachea and Larynx.—A fall upon the neck across a hard object may cause a fracture of the trachea or larynx. There may be abnormal mobility and a kind of crepitus. Almost constantly one finds dyspnea, blood expectoration and emphysema of the neck. "Undoubtedly, expectant treatment, pure and simple, when there is no depression of fragments and no marked emphysema or dyspnea, is attended by very satisfactory results in a certain number of cases; but these must always be closely watched, the patient kept absolutely quiet. . . . Even after simple fissures, submucous hemorrhages and edema may cause sudden danger of suffocation; therefore the development of increasing dyspnea is always to be considered as an indication for tracheotomy, or intubation where it is practicable."[1]

Jackson[2] reports an interesting case of "psychic trauma to the larynx." Ryan[3] describe a case of hemorrhage into the thyroid gland resulting from muscular effort. In his discussion of this subject, Ryan says that "sometimes hemorrhage is so severe that coma and death ensue even in spite of operation "

The following table, compiled by Stimson, shows the relative frequency with which the cartilages of the larynx and trachea are fractured:

	Cases	*Deaths*	*Recoveries*
Thyroid alone	24	18	6
Cricoid alone	11	11	
Thyroid and hyoid bone	5	3	2
Thyroid and cricoid	9	9	
Thyroid and cricoid and hyoid bone	2	2	
Thyroid and cricoid and trachea	2	2	
Cricoid and trachea	2	2	
Cricoid and trachea and hyoid bone	1	1	
"Larynx"	7	3	4
Trachea alone	4	3	1

Superficial skin wounds of the neck, whether lacerated, incised or puncture wounds, are treated in accordance with the same rules laid down in the chapter on wounds of the head. The external jugular vein and other large veins of the neck are likely to be the cause of very profuse hemorrhage when they are wounded. The carotid artery, however, is so deeply situated that it is rarely wounded even in the most determined suicidal attempts. The writer has seen a *cut-throat wound* of the neck of such depth as to sever both the trachea and

the esophagus without injuring the carotid artery. Those cut-throat wounds which are high up in the neck are much less dangerous to the great vessels than those which are situated just above the sternum. The thyroid cartilage and even the hyoid bone seem to have the power of lessening the force of the wounding weapon. Few patients with a severed carotid artery or jugular vein are saved. Death occurs in a few minutes. Should such a person be seen immediately after the injury, digital compression may save his life. "The fingers must be thrust backward at the front edge of the sternomastoid until the great vessels are compressed firmly against the sixth cervical vertebra."[4] A finger tip thrust into the open end of the gaping vessel may serve

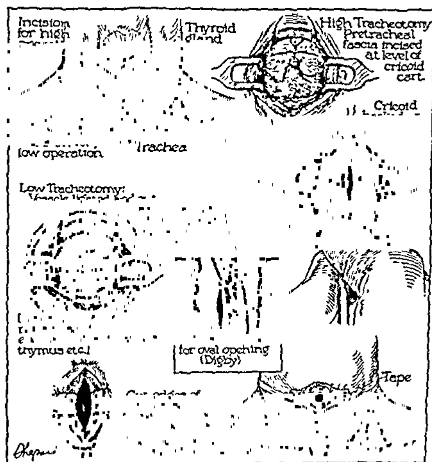


Fig. 159.—Steps in high and low tracheotomy. (Drawn by Shepard; reproduced with the permission of Johnson & Johnson.)

to control hemorrhage temporarily. Andrews[4] calls attention to the difficulty of securing a severed carotid artery at the bottom of a deep incised wound and says that it is often more advisable "to incise the skin at a new point and ligate the main trunk in continuity proximal to the wound." Wounds of the internal jugular or other large veins of the neck are dangerous not only because of hemorrhage but because of air embolism. Hemostasis in these cases may be accomplished by external pressure or, better, by ligature.

Shawan[5] reports a case of a stab [illegible] the neck in which the spinal membranes were punctured and le[illegible] rebrospinal fluid followed. There was com[illegible]ecovery after tl[illegible] of the knife blade.

Wounds of the Trachea and Larynx.—These wounds are of importance because the entrace of blood into the trachea may cause hemoptysis and alarming dyspnea. Air and bloody froth rush out of the wound, and prompt intervention is required. In such cases it is best to have the patient lie prone with the head lower than the chest. If this wound be very large it will be desirable to attempt closure under general, intratracheal or rectal anesthesia with catgut sutures. Where there is a transverse wound just above the pomum adami, Lejars advises first checking all the bleeding and then *not* introducing deep or superficial sutures but merely keeping the patient quiet, with the head held in the flexed position. If the wound is in the thyroid cartilage, this writer advises preliminary tracheotomy (Fig. 159) and then the careful introduction of sutures which do not pass through the mucous membrane. In cases of complete transverse laceration of the trachea, the proximal end retracts, and it is imperative as a first-aid measure to seize and draw this lower end out of the skin and, if necessary, fix it to the skin by sutures. Deliberate repair of the trachea may be done later. Rieman and Goldsmith[6] report a dramatic case of subcutaneous rupture of the trachea in a boy of 7 years with subcutaneous emphysema from the head to the knees who recovered after tracheotomy.

Wounds of the Esophagus and Thoracic Duct.—These wounds are too involved for such treatment as might be included in minor surgery.

Sprain of the Neck.—Sprain of the neck involves the wrenching of the ligaments attaching the cervical vertebrae. A strain of the neck is an overstretching of the muscles of the neck. The cause in either case is the same, a violent wrench of the head from one side to the other. It may occur in a child who falls out of bed on the head or a football player who is tackled about the neck. The treatment of this condition is symptomatic; rest, hot fomentations, and the employment of general massage will be of value. Counterirritants, such as chloroform liniment and iodine ointments containing methyl salicylate, are also useful.

"Distortions" of the Cervical Vertebrae.—Blows upon the head may bring about a partial loosening of the intervertebral ligaments so as to permit "distortion" or very slight subluxation of the cervical vertebrae. This injury is not recognized without the aid of roentgenograms of the neck taken laterally. The treatment demands rest in bed with traction [illegible] weeks and, generally, [illegible] ng case is of interest: [illegible] event which involved his floating with his head held in the water for as long a time as he was able to hold his breath. When the limit of endurance was reached, he jerked his head out of the water by violently extending his head He immediately experienced some pain in the *front of* his neck He was not seriously inconvenienced for a day or two, but with continued play and exercise his neck became more and more painful and he held it in a fixed position because of the protective spasm of the neck muscles. The *x*-ray examination showed avulsion of a very small fragment of bone from the anterior surface of the sixth cervical vertebra. The child was placed in bed, the head of which had been elevated some 10 inches, and 3 pounds of traction was put on the neck by means of a head halter (Fig. 160). In a few days the boy was free from symptoms, and after two weeks the head traction was removed. Thereafter the symptoms did not return

Dislocations and Fractures of the Cervical Vertebrae.—These injuries are often of such extreme seriousness as to require major surgical measures.[7] The laminagraph[8] supplies a more accurate roentgenogram of the cervical spine. Very slight fractures and some dislocations of the cervical vertebrae

without cord symptoms (Fig. 161) may be treated by halter traction or by plaster cast applied with traction upon the head so as to produce extension. Freiberg[9] has emphasized the increase in efficiency of head traction if friction is eliminated. For this purpose he has devised a pillow platform resting on

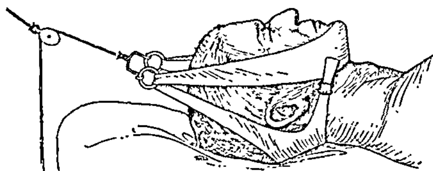


Fig. 160.—Halter for head traction.

rollers to support the head (Fig. 162). Crutchfield[10] reports very favorable experience with skeletal traction in 29 cases of fracture-dislocations of the cervical portion of the spine. The traction is applied with the author's special tongs inserted directly in the vertex of the skull. Twenty-five pounds may be



Fig. 161.—Mild compression fracture of the fifth and sixth cervical vertebrae.

used for dislocations in the middle and lower thirds of the cervical portion of the spine and 10 to 15 pounds in the upper third. The tongs devised by Barton[11] for this purpose are applied to the greatest convexity of the parietal bone. Barton's frame is also useful in adjusting the traction. Peyton et al.[12] obtain skeletal traction by means of stainless steel (no. 5) fish hooks from

which the barbs have been removed. Under local or intravenous anesthesia, one fish hook is placed under each zygomatic arch, about 1 inch anterior to the external auditory meatus.

Warshaw[13] reported a case of complete forward dislocation in which full reduction of the dislocation was secured by forcible traction and counter-traction under anesthesia without subsequent immobilization. There was no injury of the spinal cord. A few peripheral nerves were involved. The author believes that the fact that the patient made a permanent recovery without any form of immobilization is of interest, in view of the prevailing view that hyperextension in some form of apparatus or plaster is necessary over a long period of time. Eikenbarry and LeCocq[14] "feel very strongly that dislocations of the cervical spine, with very few exceptions, should be reduced at once, and under full anesthesia. If cord injury has not occurred, a complete recovery should be expected following complete reduction. Traction in bed,"

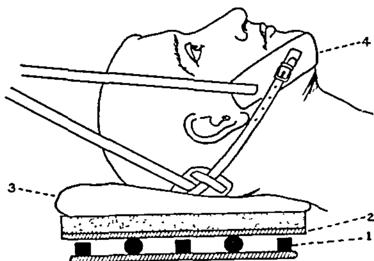


Fig. 162.—Vertical section of the apparatus in use; *1*, the tray; *2*, the top resting upon the rollers and covered with layer of sponge rubber; *3*, small pillow of the same size as the top, *4*, the halter, which should impinge upon the chin and not upon the neck. (Freiberg, A. H.: J. Bone & Joint Surg. 20: 213, 1938.)

they say, "is not likely to effect reduction, and much valuable time may be lost in making the effort."

Brookes,[15] who has given much careful study to dislocations of the cervical portion of the spine, deprecates the delay in recognition of these injuries and emphasizes the importance of immediate and positive reduction by the closed technic, "followed by full immobilization in plaster cuirass."

Stimson and Swenson[16] studied 27 cases of unilateral dislocation of the cervical portion of the spine without fracture. The *x*-rays must be carefully made. They state: "When the diagnosis has been established, treatment should be at once instituted. Two methods are available—manipulation, preferably under a general anesthetic, or traction by means of [illegible]

[illegible] cases. In the [illegible] s reduced by manipulation without anesthetic, 4 were reduced by manipulation under nitrous oxide gas-oxygen, and the 21 remaining by head traction which was maintained usually from

eighteen to forty-eight hours. One case was reduced in two hours of head traction, 10 pounds applied by a Crile head-piece. The method of manipulation most frequently used is attributed to Walton who described it in 1892 and consists of 'extending the head diagonally backward toward the side of the convexity of the neck,' thereby elevating the articular [illegible]

In a lat[illegible] vertebrae [illegible] very slight but to occur when the muscles are 'off guard,' as for example when the patient has just awakened. A sudden kink on stretching in bed, a turn in answer to a call, a jerk of the head to catch a forward pass, a twist in taking off a dress over the head have all been cited as the cause for the symptoms from which the patient sought relief. Two of the series received their injuries in motor accidents and two in diving.

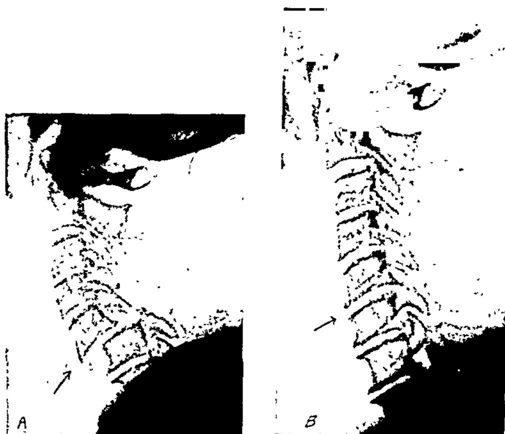


Fig. 163.—*A*, Recent dislocation. *B*, First follow-up film made on the morning after the application of twenty-five pound (skeletal) traction. (Crutchfield, W. G.: J. Bone & Joint Surg. 20: 696, 1938.)

"Following such a sudden twist as one of those just described the patient feels sudden pain and finds that he cannot straighten his head. The pain usually subsides quickly, only to recur when motions of the neck are forced, but it and the disability are usually sufficiently definite to force the patient to seek medical attention fairly soon. He often volunteers the fact that it does not feel just like a stiff neck. [illegible] to one [illegible] usually [illegible] already [illegible] ard the opposite side. Passive motions bring out the same manifestations. In other words, if the head is tilted to the right the right ear can be brought down toward the right shoulder but on attempting to bring the left ear to the left shoulder a definite resistance is encountered and the patient usually complains of pain. Rotation to the affected side may or may not be impaired, but lateral flexion is invariably resisted. Muscle spasm is usually present and

is found on the 'long' or affected side in contrast to torticollis, in which the spasm is on the 'short' side toward which the head is bent. There is usually tenderness over the affected vertebra on the 'long' side. Three patients complained of pain radiating down the shoulder and arm. No other signs or symptoms of cord or nerve involvement were noted. . . .

"The conclusive proof of the diagnosis of subluxation, however, lies in the stereolateral roentgenograms, which will show the sliding forward of one articular facet on the one beneath it."

Treatments included head traction, hyperextension on an air mattress and manipulation under general anesthesia. Patients with more severe involvement were immobilized in a plaster collar for four weeks

Berkheiser and Seidler[18] have made an interesting study of nontraumatic dislocations of the atlantoaxial joint, with the following conclusions:

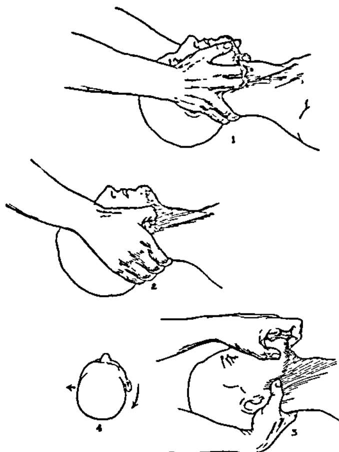


Fig. 164.—1, 2, 3 *illustrate three different grips for reducing cervical luxations.* 4 shows that abduction to the left must be performed and rotation down and back on the right. (Cotton)

"1. In 5 cases of nontraumatic dislocation of the atlantoaxial joint, occurring in children from eight to eleven years of age, 1 was a bilateral forward dislocation while 4 were unilateral—two anterior and two posterior.

"2. These occurred as a complication from one to two weeks after an acute upper respiratory infection.

"3. They presented a rather characteristic torticollis deformity, with marked fixation and pain on attempted motion

"4. Roentgenograms showing this dislocation are difficult to obtain when the extreme deformity is present, and, hence, they are usually interpreted as negative. But when a good view of this region is seen, the dislocation is shown in an overlap of the lateral articulating facets. As the dislocation is further reduced, the overlap diminishes and the joint space reappears

"In the unilateral anterior dislocation the chin deviates to the opposite side, while in the posterior dislocation the chin deviates toward the same side.

"The lateral view in the anterior dislocation shows the anterior arch of the atlas to be misplaced relatively far forward with respect to the odontoid.

"5. All these dislocations were reduced, 4 by means of constant traction in hyperextension and the other case by forcible manipulation under anesthesia." (See Fig. 164).[19]

Fractures of the Hyoid Bone.—Fractures of the hyoid bone are relatively rare occurrences. In 1864 Gurly[20] collected reports of but 27 cases. The large majority of the cases were fractures of the greater cornua. In a few cases the body was injured and in none the lesser horn. In isolated fractures of the hyoid bone the symptoms, according to Stimson,[21] are characteristic. There is "sharp pain at the seat of the fracture, increased by pressure, speaking or swallowing; swelling in the same region appearing soon after the accident and due in part to extravasated blood; recognizable displacement or mobility of the fragment; crepitus; and sometimes free bleeding from the mouth, the result of perforation of the mucous membrane of the pharynx by the bone." There is painful limitation of the movements of the tongue, with marked pain on swallowing. Reduction of the displacement should be attempted, if necessary with the assistance of a finger in the pharynx. Tube feeding and a stiff collar may be necessary.

INFECTIONS

Cellulitis.—Diffuse cutaneous and subcutaneous infections occur in the neck following wounds which may be very trivial. These infections are manifested by pain, swelling and diffuse redness. There is no evidence of localization. The systemic disturbance may be rather marked with elevation of temperature and malaise. Penicillin and/or sulfonamides are usually indicated. (See Penicillin.) Rest and continuous hot boric fomentations are indicated. *Occasionally the infection will localize, and an abscess cavity will form.* When the induration surrounding the localization has subsided and one may be reasonably sure that there is a well marked defensive wall about the abscess, incision with a very sharp knife under gas anesthesia or ethyl chloride will hasten the recovery. The incisions in the neck should be made in the skin creases (see section on Tumors and Deformities of the Neck) and somewhat smaller than is ordinarily the case elsewhere because conspicuous scars are to be avoided. A small amount of loose gauze packing or a very small soft rubber tube should be inserted in the wound to prevent premature superficial closure. *Penicillin and the sulfonamides are administered.*

Erysipelas.—Erysipelas of the neck is generally secondary to that of the face or scalp, and the same rules of treatment described under erysipelas of those regions obtain in the neck. (See the sections on Erysipelas.)

Furuncles and Boils.—Furuncles of the neck are particularly prone to occur in men because of the irritating effect of stiff collars. The continued abrasive pressure of a collar coupled with the presence of staphylococci on the surface and in the skin is liable to bring about staphylococcic infection or boils. (See the section on Furuncles and Carbuncles.)

Carbuncles.—*The posterior side of the neck is the most common site of* carbuncles, particularly in men. The incidence of carbuncles of the neck is far greater in men than in women, a circumstance which is thought to be due to the irritative action of the collar. Carbuncles of the posterior region of the neck may begin with a small localized cutaneous infection which generally has been traumatized by squeezing or picking with a needle, or it

may begin as a more diffuse infection without a visible wound of entry. The portal of entry, which is always external, is most commonly a hair follicle. The rate of progress of development of the carbuncle depends on the virulence of the invading organism. Some types of hemolytic staphylococcus will make a very severe lesion with marked systemic prostration, elevation of pulse rate and temperature, and a wide area of induration on the neck. There may be little, if any, pain and no visible evidence of localization. It is justifiable to treat very early carbuncles of the neck by hot fomentations and penicillin for a period of perhaps twenty-four hours. If *marked* encouragement is not obtained radical surgical treatment is by far the safest course. In smaller carbuncles the crucial or three line cross incision with generous undercutting of the flaps and excision of the necrotic tissue will suffice. For large carbuncles the double cross incision with removal of the central square will be advisable. For the details of the treatment of furuncles and carbuncles of the neck the reader is referred to the earlier section on furuncles and carbuncles.

Ligneous Phlegmon (Woody Phlegmon; Reclus' Disease).[22]—Ligneous phlegmon was first described by Reclus, in 1894. It is an extremely chronic suppurative inflammation of the subcutaneous tissues of the anterior and lateral portions of the neck. Over weeks and even months, board-like hardness and induration develop. For a considerable period of time the usual signs of inflammation are absent. In advanced cases the larynx, trachea and floor of the mouth are involved. There is little pain, but the movements of the neck are restricted because of the stiffness Collections of pus will finally become evident. The cause is obscure. According to Freeman,[23] the "diagnosis is difficult, as may be appreciated from the fact that ligneous phlegmons are nearly always mistaken for carcinomatous or possibly tuberculous infiltrations arising from the cervical glands. Even the advent of suppurative foci does not always settle the question, as these appear sometimes in connection with cancer, so that in order to be certain in such a case one would have to wait until the patient recovered, which might require three or four months." The treatment is unsatisfactory. Individual abscesses are opened as they present themselves. Hot fomentations may hasten the formation of these abscesses.

Deep Infections of the Neck.[22]—The majority of deep infections of the neck are of such a serious nature that their consideration is more properly placed in the field of major surgery. The patients are very ill. There may be dysphagia and dyspnea. There is pronounced swelling of the region, but the overlying skin, while edematous, is rarely red. The swelling is very hard, and it is unusual to detect fluctuation, because of the tense deep cervical fascia. There is pain upon pressure. Ford[24] says, "In the words of Thomas Carmody, of Denver, '[illegible]

use blunt dissection, see the veins, retracting them where possible or cutting between ligatures, and know the relations of several anatomic landmarks, so that, where deep induration exists, the hand may be steadied by the recognition of a few." Orton[25] says: "Delay in instituting early and courageous treatment for deep infections of the neck may prove disastrous."

Barnhill[26] has given an excellent description of the five potential spaces in the anterior portion of the neck and the surgical approach to each when it becomes filled with pus. The *sublingual space* lies in the floor of the mouth. Infection in this space is known as *Ludwig's angina* and has a mortality of about 50 per cent. In early cases the incision may be made inside the mouth. In later cases incision may be made below and parallel to the mandible, or, as Dorrance[27] advises, a midline incision may be made from the tip of the chin to the hyoid bone, with another incision outward under the angle of the jaw. The incisions go through the deep fascia. The *retropharyngeal space* is at the top of the nasopharynx, between the mucosa and the muscles resting on the vertebrae. This space is drained by means of an incision through the mouth (see Retropharyngeal Abscess), the head hanging down to avoid suffocation caused by the entrance of pus into the trachea. The *pharyngomaxillary space* lies in the extreme upper portion of the neck just external to the faucial tonsil and is bounded by the buccopharyngeal fascia, the base of the skull,

mastoid muscle. After two or three days of observation this swelling was noted to be prolonged downward to the supraclavicular region. Immediate intervention was determined upon, and an incision was made parallel to the anterior border of the sternomastoid muscle. Pus was evacuated from a large abscess cavity which pointed downward behind the clavicle toward the mediastinum and upward along the carotid sheath. The surgical treatment of these abscesses requires that the use of sharp dissection be strictly limited to the more superficial regions. After the skin and subcutaneous tissues have been incised it will be well to divulse the underlying tissues by means of a hemostat or blunt-pointed scissors. By carefully proceeding in this manner one can break into the abscess cavity. The opening into the cavity should be widely spread and a small amount of gauze packing loosely inserted. The purpose of this packing is to maintain the superficial opening until discharge has finished and the cavity has been filled up by granulation tissue from the



Fig. 166.—Suppurative cervical adenitis. (Children's Memorial Hospital, Chicago. Courtesy of Dr. A. H. Montgomery.)

bottom. It will be well to change this packing daily. A soft rubber tube occasionally is of service and may be sutured into the wound with one catgut suture, but care will be necessary to prevent the rubber tube from pressing on the carotid artery or jugular vein or other important structures, because of the fear of pressure erosion. After the abscess cavity has been adequately opened and drained the supplementary use of hot boric fomentations will hasten the recovery. When the abscess cavity has become very small and the inflammation has subsided, it will be necessary to continue the insertion of drains. A dry dressing generally will suffice. Penicillin and/or sulfonamides will also be used.

Chronic cervical adenitis may be due to the delayed resolution of acute cervical adenitis, or it may be due to tuberculosis. In the case of the former the history generally will furnish the diagnosis. In the case of the latter a general physical examination will furnish the clew. *Tuberculosis of the cervical lymph nodes* is treated by conservative measures. Rest, abundant

food, fresh air and sunshine will most often cause these swellings to melt away. *When this is impracticable the use of ultraviolet radiation of the* entire body is often of benefit. The surgical excision of tuberculous "glands" of the neck is of much less frequent occurrence than formerly, save in cases of fluctuant abscesses. These are incised, drained, curetted, swabbed with iodine and packed. Clute[34] has made an interesting study of some 140 cases of tuberculosis of the cervical lymph nodes. There were no deaths in the series. The best results were obtained in the cases in which treatment was given early. In some cases a combination of *x*-ray and surgical treatment gave good results. Meyer[35] says: "While *x*-ray produces inflammation with subsequent encapsulation, it also seemingly often causes a breaking down of the glands with dissemination to other parts of the body. The incidence of miliary, pulmonary and bone tuberculosis immediately following *x*-ray treatment to tuberculous cervical lymph glands is too high to be coincidental. . . . The pendulum has now swung back to radical excision of tuberculous cervical lymph glands in non-pulmonary cases, and in pulmonary cases excision only when the mass produces symptoms." In dissection of supraclavicular nodes on the left side of the neck, great care must be observed to avoid injury to the thoracic duct. It is important to remove all sources of infection, such as diseased tonsils and abscessed teeth. Nerve injuries occurred with diminishing frequency with better understanding of the anatomy. This author believes that the surgical treatment is the procedure of choice for the average patient who cannot afford the time or expense of prolonged hygienic treatment. Miller[36] says: "We believe that where these nodes are discrete, where the technical difficulties of operation are not insuperable, and where there is no active pulmonary or general disease, radical excision should be given serious consideration as the treatment of choice." Waugh[37] reports 21 cases of tuberculous cervical adenitis treated with immobilization in plaster of paris.

Suppurative Parotitis.—(See section on Acute Pyogenic Parotitis under Infections of the Head and also Postoperative Parotitis.)

Specific Infections of the Neck.—Of the specific infections which involve the neck, tuberculosis, syphilis, anthrax and actinomycosis have been considered previously.

Ludwig's angina (*angina ludovici*) is an acute purulent inflammation of the floor of the mouth which usually is due to the streptococcus. The symptoms are those of severe sepsis, with the formation of a tense brawny swelling in the submaxillary region. Great pain, dysphagia, and sometimes dyspnea are the characteristic symptoms. Penicillin should be given in large doses.

Taffel and Harvey[38] say:

"Ludwig's angina is a surgical emergency and demands immediate operation. The cardinal symptoms appear early in the disease and can be easily recognized. They include (1) a tender swelling in the submandibular area of the neck; (2) elevation of the tongue; and (3) edema of the floor of the mouth. The high mortality in this disease is due not to some overpowering and occult virulence of the infecting organisms, but more often to a mechanical obstruction of the respiratory pathway. The primary object of the operation is to relieve and preferably to prevent this obstruction by releasing the tension within the submandibular space. This can be accomplished with safety and certainty only by complete transection of the deep cervical fascia and the mylohyoid muscle. A thorough decompressive procedure should be performed as soon as possible after the diagnosis is made. Except in extremely extenuating circumstances, the operation should be performed under local novocain anesthesia." The prognosis in the more advanced cases is grave.

Arthritis of the Cervical Portion of the Spine.—Patients complaining of painful neck and presenting tender points along the transverse processes of the cervical portion of the spine and limitation of motion should be investigated for the existence of arthritis. The diagnosis of arthritis of the cervical portion of the spine is confirmed by the *x*-ray, which will show some lipping of the vertebrae or the presence of calcareous deposits in the intervertebral ligaments and upon the vertebrae themselves. The treatment is twofold: local and general. The main features of the local treatment are rest and heat. Rest is best obtained by putting the patient in bed with the application of traction upon the neck. The head of the bed is elevated from 4 to 6 inches. A canvas halter is placed beneath the patient's chin and occiput, and attached to a spreader which in turn is attached to a rope passing over a pulley. From 3 to 5 pounds of weight is applied to produce traction. While the traction is being maintained the attendant should be instructed to apply continuous moist heat to the neck. This is best accomplished by first placing upon the pillow an electric pad. Upon the electric pad is placed a rubber sheet or some other waterproof material. Upon this in turn is placed an abundant quantity of gauze or flannel, which is moistened at regular intervals with boric solution or a solution recommended by Dr. Philip Lewin, which contains:

	Cc.
Tr. opii	30
Liq. plumbi subacetatis dil.	40
Phenol. ½ of 1 per cent	50
Extr. hamamelis	60

The systemic treatment involves a careful search for possible foci of infection. All carious teeth should be removed, and those suspected of having root abscesses should be *x*-rayed and, if necessary, extracted. If the tonsils present evidence of infection they should be removed. The sinuses, particularly the ethmoids, should be carefully examined by a rhinologist and given appropriate treatment if necessary. Infection in the middle ear should be searched for and treated. Chronic infection of the appendix or gallbladder may play a role. Of particular importance is a consideration of the intestinal tract, which may be regarded as a focus of infection. To this end anticonstipation treatment should be instituted. It is a common occurrence to be assured steadfastly by the patient that he had a daily bowel movement, but, in the words of Paul Magnuson, "the train may be on time but a day late." It also will be well to curtail the amount of protein ingested.

FIRST AID IN MAJOR SURGICAL INJURIES OF THE NECK

In cut-throat wounds the first-aid treatment will involve the control of hemorrhage. If the jugular vein or the carotid artery is cut, an effort should be made at once to ligate it, if necessary using unsterile ligatures. Where the trachea and esophagus both have been cut, the first-aid treatment is directed toward the prevention of asphyxia from the inspiration of blood or vomited stomach contents. To this end the head and neck of the patient are placed at a lower level than the body.

In cases of suspected fracture of the cervical vertebrae with the head fixed in an unnatural or semirotated position, or if there may be paralysis of the extremity following a fall upon the head, as in diving, the first-aid treatment

is directed toward the transportation of the patient to the hospital with the minimum amount of disturbance to the neck (Fig. 167). It is desirable that the heaid, neck and trunk move as one piece. An ill advised attempt to change the postion of the head may mean instant death.[39]



Fig. 167.—Brace suitable for use in transportation and handling of patients with injuries to the cervical vertebrae. (Wright, L. T.: J. A. M. A. 106: 1467, 1936.)

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CHAPTER XII

TUMORS AND DEFORMITIES OF THE NECK

Placement of Incisions in the Neck.—Holman[1] wisely emphasizes that incisions in the neck should parallel the normal skin lines and preferably be in the skin creases (Fig. 168). He says: "An incision that crosses the normal lines of the skin in a region characterized by constant motion as in the neck will almost invariably produce a thick unsightly scar that is likely to become more prominent as time passes and that may even assume the character of a keloid. The placement of incisions in the neck, therefore, is particularly important in women, who may suffer untold mental anguish from badly placed incisions that produce keloidal scars in conspicuous and constantly self-observed areas."

Benign Tumors.—The neck is the site of certain benign tumors. *Lipoma, hemangioma* and *lymph* cysts occasionally are found. Most lipomas are readily removed under local anesthesia. Hemangiomas are highly vascular, and their removal is fraught with some danger. It can more properly be considered as a major surgical problem.

Dermoid Cysts and Sebaceous Cysts.—These cysts have been found in the neck and are removed in the usual manner. (See the section on Sebaceous Cysts.) Hair cysts are small inclusions which are due to the ingrowing of short cut hair. A hair will often curl up upon itself intracutaneously and attain a length of 1 cm. or even several inches. (Vaughan and Burnham.) *The extraction of the hair by needle or forceps is generally all that is required* for treatment. If the cyst is large, it should be opened under local anesthesia and its lining swabbed with iodine.

Glomus Tumor (*See section on Glomus Tumors*).—Glomus tumor of the neck has been reported by Ottley.[2]

Embryonal Cysts and Fistulas of the Neck.[3]—*Lateral Cervical Cysts and Fistulas* (*Branchiogenic Cysts and Fistulas*).—Cysts and fistulas which are found on one or both sides of the middle of the neck, generally about $1\frac{1}{2}$ inches from the midline, are spoken of as lateral cervical fistulas and cysts. These anomalies are usually thought to be of branchiogenic origin.[4] Hyndman and Light[5] have studied this subject and conclude that "branchial cleft anomalies (cysts and fistulae) result from a failure of absorption of ectodermal and entodermal epithelium that is buried during the growth and fusion of the branchial arches in early life. This is most probably the sole explanation, the thymic stalk playing no role. Branchial cysts, in truth, are epidermoid cysts of the neck whose parent epithelium was buried during the development of the branchial apparatus. Their characters are more varied, of course, than those of the commoner epidermoid or inclusion cysts owing to the activity of entodermal or ectodermal epithelium or both. Many of the submaxillary cysts and so-called 'ranulae' are of branchial origin."[6]

A cyst will be manifested by a small rounded nodule in the neck, which, if large enough to be palpated, may be shown to have fluctuation. The fistula may be complete, that is, extend from the buccal cavity to the outside of the neck, or it may be incomplete, extending from the subcutaneous tissues to

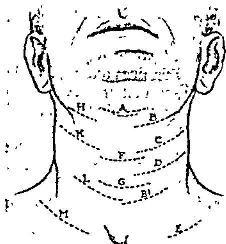


Fig. 168.

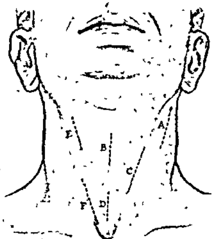


Fig. 169.

Fig. 168.—Proper placement of incisions in the neck paralleling the normal lines and folds of the skin: A, for drainage of submental abscess; B, for excision of congenital sinus partially mobilized through incision B; B[1] for mobilization of sinus tract presenting at B[1] but penetrating pharynx at B; C, for excision of carotid tumor or branchial cyst; D, for diverticulum of the esophagus; E, for scalenotomy or phrenic interruption; F, for cricothyreotomy; G, for tracheotomy; H, for drainage of cervical abscess at angle of the jaw; K, for exposure of internal or external carotid, L, for exposure of common carotid; *M, for exposure of brachial plexus.*

Fig. 169.—Placement of incisions as sometimes improperly recommended, all of which transgress the rule not to cross creases of the skin in the neck: A, for excision of a carotid tumor; B, for cricothyreotomy; C, for lateral esophagotomy; D, for tracheotomy; E, for exposure of the external carotid artery; F, for exposure of the common carotid artery. (Holman, E.: Surg., Gynec. & Obst. 78: 533, 1944)

the skin or from the subcutaneous tissues to the mouth. The cyst gives practically no symptoms except its rather unsightly appearance. A fistula is complained of by the patient because of the continual discharge on the surface of the neck. A drop of watery pus is practically always present at the orifice of the fistula. Cases have been reported in the literature in which the fistula

was of such size, patency and length, that bread crumbs and other particles of food found their way down from the mouth out on the surface of the skin at the neck. Wangensteen[7] has suggested a method which is of great aid in the differential diagnosis between neck cysts and cervical adenitis. The cysts may be aspirated and injected with a medium opaque to the x-rays, whereafter the diagnosis of cyst is readily made by x-rays. The injected medium is reaspirated after the x-ray has been made. The lateral cervical cyst generally may be removed under local anesthesia without great trouble. The excision of the fistula may also present considerable difficulty and be a major surgical problem.[8] The procedure generally employed is to inject into the sinus methylene blue or melted paraffin (Fig. 170) and by cautious dissection excise

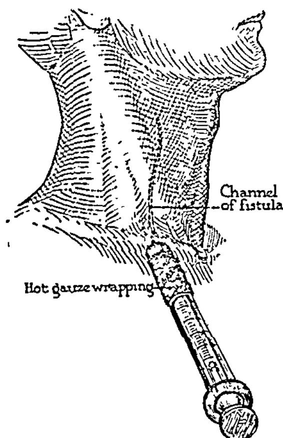


Fig. 170.—Method of injecting paraffin into a lateral cervical fistula. Note that the needle is wrapped in hot moist gauze.

it up to the buccal cavity and there cut it off and turn the stump into the mouth and fix it there by a purse string suture.

Cutler and Zollinger[9] report the cure of two cervical fistulas by injection of modified Carnoy's solution. This solution is made up as follows:

Absolute alcohol	6 cc.
Chloroform	3 cc.
	1 cc.
	1 Gm.

The skin adjacent to the fistula must be carefully protected with vaselin.[10]

Thyroglossal Cysts and Fistulas.—Cysts and fistulas in the midline are

generally remnants of the embryonic thyroglossal duct, although sebaceous cysts have been found in this location. Payne[11] believes that the recognition of a thyroglossal cyst "should be easy for it always occurs in the midline between the symphysis mentis and the thyroid cartilage. It should, however, be differentiated from ectopic thyroid tissue, enlarged submental gland, inclusion dermoids which are always found in the median line, lingual dermoids, submental cysts which develop from the cervical sinus and often are called ranulae and from the true cervical fistula which is of branchiogenic origin and always situated lateral to the midline along the anterior border of the sternomastoid muscle.' Bailey[12] points out that a thyroglossal cyst tends to move upward when the tongue is protruded. Clute and Cattell[13] believe that thyroglossal cysts and sinuses are of relatively rare occurrence and that the diagnosis is made upon the finding of a single midline tumor or sinus in the region of the hyoid bone which moves with deglutition. The treatment of



Fig. 171.—Hygroma, which was treated with radium and was reduced in size when the child was removed, against advice. (Children's Memorial Hospital, Chicago. Courtesy of Dr. Joseph Brenneman.)

thyroglossal cysts and fistulas is identical with that of lateral cysts and fistulas.[14] Eliason[15] reports five inclusion cysts of the hyomandibular region and gives a very interesting account of their embryologic origin (Figs. 141, 142). The treatment is surgical excision.

Hygroma Colli Cysticum.—The best understanding of hygroma colli cysticum may be obtained from the careful studies of Goetsch.[16] He says:

... cases where pressure
... substances
odds
age,

Hydatid Cyst.—Hydatid cysts are rarely found in the neck. Fraser[18] reports a case of hydatid cyst in the neck of a woman 65 years of age. It had been present five years without symptoms and was easily excised.

Cartilaginous Nodules.—Embryonic cartilaginous remnants may be found in the skin of the neck or as accessory appendages to the ear. Their removal is safely and easily accomplished under local anesthesia.

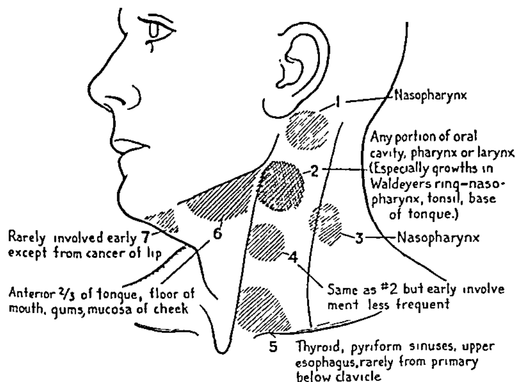


Fig. 172.—Various lymph node groups with the most likely sites of the primary lesions which may cause the metastases. (Martin, H., and Morfit, H. M.: Surg., Gynec. & Obst 78: 133, 1944.)

Cervical Lymph Node Metastases.—Martin and Morfit[19] make the following statement: "It is not generally realized that cervical metastasis frequently occurs as the initial, and for a time, the only symptom from an otherwise silent primary malignant tumor in the upper respiratory or alimentary tracts or, rarely, from a primary growth in some viscus below the clavicle. Such silent primary lesions are often not suspected or at least not found when the patients first seek medical advice because of cervical tumors (cervical lymph node metastases). Even after repeated and thorough examinations, the primary growth may not become evident for months or even years, and it is certain that many persons die of widely disseminated cancer undiagnosed as regards the origin of the growth." The following table is from the article by Martin and Morfit. In 11 other cases the primary lesion was below the clavicle.

SITE OF THE EVENTUALLY DISCOVERED PRIMARY LESION ABOVE THE LEVEL OF THE CLAVICLE IN 152 CASES IN WHICH THE FIRST SYMPTOM WAS THE PRESSURE OF A CERVICAL TUMOR (LATER PROVED TO BE CARCINOMATOUS)
(1933–1937)

Site in which primary lesion was eventually discovered	Number of cases	Per cent of total
Tonsil	35	23
Nasopharynx	33	22
Tongue	29	19
Extrinsic larynx	22	14
Floor of mouth	10	7
Pharynx	9	6
Thyroid	7	5
Palate	4	3
Paranasal sinuses	1	0.6
Gums	1	0.6
Intrinsic larynx	1	0.6
Total number of cases	152	100

Cervical Rib.—Patients presenting themselves with the complaint of continual pain radiating down the arm, particularly that which has a constant area of distribution, will suggest the presence of a cervical or supernumerary rib. The presence of such a rib is determined by *x*-ray examination.[20] In the diagnosis it is important to differentiate this condition from brachial neuritis. Section of the scalenus muscle, as suggested by Adson,[20] is now considered preferable to excision of the rib. Leri[21] states that as the normal variation of the processes is very wide, care must be taken in ascribing nerve disturbances of obscure origin to a cervical rib or a hypertrophied transverse process.[22]

Torticollis or Wryneck.—Wryneck is a condition in which there is shortening of the sternocleidomastoid muscle and its associated structures. Fraser[23] describes six varieties as follows:

"1. *Congenital wryneck,* in which the error becomes apparent shortly after birth and progressively increases in degree.

"2. *Acute wryneck,* in which the muscle is the site of a primary or of a secondary infective involvement.

"3. *Traumatic wryneck,* in which injury to the muscle or its associated structures has resulted in the formation of fibrous tissue and subsequent shortening.

"4. *Spasmodic wryneck,* in which a nervous error is responsible for an intermittent or spasmodic contraction of the sternomastoid and it may be of associated muscles.

"5. *Postural wryneck,* arising secondary to deformities of the spine, or in compensation for an ocular error.

"6. *Paralytic wryneck,* following paralysis of the trapezius and sternomastoid muscles. The usual cause is the division of the associated nerves during operation for tuberculous cervical glands.

"All varieties are met with in childhood, but the congenital type forms the great bulk of the cases."

The etiologic factors are obscure. Heredity probably plays a part. The various theories of explanation include the traumatic theory, the infective theory, the theory of intrauterine disease, the nerve paralysis theory and the

very reasonable theory that the process is similar to ischemic or Volkmann paralysis.

In a case of slight congenital wryneck the child should be given massage and movement to stretch the shortened muscle at once.[24] In the more marked cases operation should be done when the child has reached the age of 1 month, if he is seen at that time. Subcutaneous tenotomy or open myotomy will be done. In the former operation each head of the sternomastoid is divided close to its sternoclavicular insertion. The cut is from within outward, and the muscle is held tense during the operation. In the latter operation the procedure is much the same except that the open operation enables the cutting to be done under direct vision and there is less danger of damaging the underlying internal jugular vein. After operation a corrective bandage is applied for two weeks, and this is followed by a brace collar for six months. The collar is removed daily for active and passive movements.

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CHAPTER XIII

INJURIES AND INFECTIONS OF THE TRUNK

INJURIES OF THE TRUNK

Contusions.—The trunk is particularly liable to contusions and bruises. All contusions of the chest and of the abdomen must be regarded as potentially serious because of the possiblity of damage to the deep underlying organs. Severe bruises of the chest wall may be extremely painful and may cause the development of a hematoma or extensive ecchymoses. Should a large hematoma develop, it will sometimes be well to aspirate it under aseptic precautions and to apply a snug bandage. The author recently operated upon an obese woman of 55 who had fallen 6 inches, striking her abdomen against a sink. Beneath the skin was a hematoma containing about 500 cc. of blood. A small bleeding artery on the anterior sheath of the rectus was ligated.

All contusions of the abdomen must be regarded as serious. Of prime importance is the taking of considerable pains to obtain an accurate history of the accident. If there is any reason to believe that an automobile has passed over the abdomen or if the patient's abdomen has been subjected to a heavy crushing force, such as having been squeezed between two cars, having been kicked by a horse or having had a heavy weight fall on it, the case should be handled with greatest circumspection. It must be remembered that in severe bruises of the abdominal wall there will be a marked degree of pain and rigidity, which will very closely simulate that of an intra-abdominal injury. The diagnosis of intra-abdominal injury cannot be made upon presence of abdominal pain and rigidity alone; elevation of the leukocyte count and of the pulse rate, the presence of shifting dulness, vomiting, pallor, the degree of shock (low blood pressure) and the *x*-ray demonstration of pneumoperitoneum are factors which will help decide the question of whether or not surgical intervention is indicated.[1]

The treatment of an intra-abdominal injury is a difficult major surgical problem.

Contusions of the flank will not infrequently cause traumatism of the kidney. The existence of a superficial abrasion in the flank following a crushing injury and accompanied by the presence of blood in the urine will establish the diagnosis. These contusions of the kidney are generally benign and require no other treatment than rest. The more severe injuries with marked hematoma and possible extensive laceration of the kidney itself often will require major surgical treatment which may include nephrectomy.

Injury to the urinary bladder should always be suspected in patients who have been subjected to crushing injuries. It is not uncommon in children. Greene[2] reported 2 cases with the appropriate major surgical treatment.

McKenna[3] has called attention to the value of intravenous urography in the early diagnosis of suspected injury to the genitourinary tract. Much information regarding the condition of the kidneys and ureters may be obtained. In regard to the bladder he says: "Excretory urography in rupture

of the bladder will show whether one is dealing with an intraperitoneal or an extraperitoneal tear."

Contusions of the breast in women are painful but are rarely accompanied by serious consequences. Practically every woman in whom cancer of the breast develops will remember having been struck in the breast at some time or other, but as this naturally happens to almost all women, it cannot seriously be regarded as an etiologic factor in cancer. A breast which has been severely bruised and which contains a large amount of suffused blood will be made more comfortable by a binder which elevates and compresses the breast.

Traumatic Fat Necroses of the Mammary Gland.—This interesting condition was first described, in 1920, by Lee and Adair.[4] A tumor appears in the breast following an injury, often after hypodermoclysis. This tumor, which may be mistaken for carcinoma, is in reality the result of an inflammatory reaction around an area of necrotic and liquefied fat. The resemblance to carcinoma may be close, although the mass is fairly well circumscribed. The tumor is extremely hard and in Lee and Adair's cases was fixed to the skin in 4 cases and to the deeper structures in 2. The tumor may appear from three weeks to ten years after the receipt of the trauma. The tumor is benign, and local excision under local anesthesia will suffice for the treatment. The gross appearance is given by Boyd[5] as follows: "The affected area is opaque, and may show one or more cysts containing liquefied fat; or the center may be simply somewhat diffluent. The area is more or less encapsulated; at least there is no evidence of infiltration. The cicatricial contraction and the yellow points and streaks of carcinoma are not observed. Although on a superficial examination there may be a resemblance between the gross appearance of carcinoma and traumatic fat necrosis, a careful study will reveal essential differences. It is possible to make a correct diagnosis on the operating table from the gross appearance." The microscopical picture is one of chronic productive inflammation in the fat. Foreign body giant cells are numerous. There are areas of necrosis and liquefaction in the fat.

All *contusions of the chest* should be considered as possibly being accompanied by fracture of the rib or scapula, and investigation should be carried out to determine if this be the case. (See Fractures of Ribs and Clavicle.)

Contusion of the heart is an extremely serious condition and may require operation. It may occur in automobile accidents when the driver is injured by striking the steering wheel. The subject has been carefully studied by Beck,[6] to whom the reader is referred for a more detailed account. Sigler[7] found demonstrable evidence of some cardiac damage, clinical, electrocardiographic or both, in 32 of 42 cases of accidental body injuries.

Contusions of the back are often accompanied by severe pain due to the bruising of the large muscles of the back. Any effort to move causes intense pain, and there is localized tenderness upon pressure. Often bed rest, external heat and sedatives are required. The tender areas are over the muscles, and pressure upon the spinous processes may be painless. One should not conclude that there is no bony injury because there is no tenderness upon the spinous processes, and when injury is suspected a roentgenogram should always be made. The treatment of uncomplicated contusion consists of rest, heat and gentle massage.

Rupture of Muscles.—*Rupture of Rectus Abdominis Muscle (Hemorrhage Into or Beneath the Rectus Muscle, Hematoma of Rectus Muscle).*—This

interesting condition has been thoroughly studied by Cullen and Broedel.[8] In their article the literature is reviewed, and 5 cases are presented. A study of the cases showed hemorrhage following both direct injury and indirect injury of the rectus muscle. When the hemorrhage is due to direct injury, the diagnosis is clear. The symptoms when it is due to indirect injury are very acute. The hemorrhage may be due to tearing of the vessels, rupture of the muscle or both. The hemorrhage is usually below the umbilicus and is limited to one side. In another series it was noted 45 times on the right side, 33 times on the left side and only 5 times above the umbilicus. Occasionally there is discoloration of the abdominal skin. When the hemorrhage is below the umbilicus, the free blood may lie directly against the peritoneum and produce irritation and pain suggestive of an intra-abdominal lesion. The authors report cases cited in the literature to show the various symptoms noted.

Hemorrhage of the rectus muscle has stimulated nearly every form of acute abdominal disease, such as appendicitis, twisted ovarian cyst, ovarian abscess, ruptured tubal pregnancy or intestinal obstruction. Babbage et al.[9] say: "Injection of 1 per cent solution of procaine hydrochloride into the right rectus muscle is suggested in all cases in which acute appendicitis cannot be excluded by the history and by clinical examination. Such injection does not relieve the pain and tenderness present in acute appendicitis."[10] In many cases the true condition remained obscure until an incision was made. In cases in which rupture of the rectus sheath had occurred, staining of the abdominal fat was always noticed. The diagnosis of this condition may be very difficult.

Causes of rupture or hemorrhage of the rectus muscle are listed. Rupture may occur from muscular exertion, but usually the patient is suffering from some debilitating or infectious disease. Rupture and hemorrhage are occasionally noted during pregnancy. Rupture often occurred following typhoid. This was thought to be caused by the hyaline or waxy degeneration of the rectus muscle which frequently occurs in this disease; these changes were known as Zenker's degeneration. Influenza or influenza pneumonia causes a similar degeneration of the fibers of the rectus muscle, and rupture and hemorrhage occur. Heart disease has a share in the causation of hematoma of this muscle. Hemorrhagic diatheses seem to have played only a minor role in the reported cases. Surgical operations are sometimes the cause of the hemorrhage, *e. g.*, when the rectus muscle is drawn strongly to one side and some bleeding is caused. Additional causes are gallbladder disease, tetanus and syphilis.

Treatment, as a rule, calls for opening of the sheath of the rectus muscle, removal of the clot, ligation of any bleeding vessels and suture of the muscle if necessary. Sometimes the blood is intimately blended with the muscle and cannot be removed. When hemorrhage is slight, no operation is required.[11]

An abscess may occur beneath the sheath of the rectus muscle, especially in cases of influenza or typhoid.

Rupture of the Pectoralis Muscle.—This subject has been discussed by Pulaski and Chandlee,[12] who say:

"Rupture of the pectoralis major muscle presents a typical clinical picture. One finds tumefaction and discoloration over the pectoral region with indentation over the rupture site. By having the patient attempt strong adduction against resistance, the separation

and the swelling increase, the lump hardens, and the pressure over it causes pain. The force with which adduction is accomplished is directly in relation to the degree of the tear. When the contraction ceases, the lump becomes soft again. Attempted motion is usually accompanied by pain over the torn muscle.

"Tears of the pectoralis may develop either by (1) excessive muscle tension, (2) direct violence, or (3) a combination of both. Two cases have been reported as spontaneous ruptures due to senile changes. Parker[13] believes old age is a predisposing factor. Of the other cases nine were attributed to strong pull on the contracted muscle, one to direct violence, and five to a combination of both direct blows and violent pull. All cases occurred in males. The tears involved the muscular portion in every case, usually the pars sternalis and the pars abdominalis, near the axillary fold. Tears of the clavicular portion and of the part attached to the sternum are less frequent. Complete tears have never been reported.

"As regards treatment, surgical repair of the muscle through suture is preferable if seen early, and plastic operation is advisable in cases where the diagnosis has been delayed. There is a normal tendency for spontaneous restoration of function, but this is slow and full power is never restored."[14]

Rupture of the Serratus Magnus Muscle.—Fitchet[15] reported 5 cases of injury to the serratus magnus muscle. A winged scapula and an ability to invaginate the overlying skin into the subscapular space, together with persistent pain, a drooping shoulder and inability to elevate the arm above a right angle, were signs on which the diagnosis was made.

Rupture of the Psoas Muscle.—In describing trauma to the psoas muscle, Michelson[16] says: "With this syndrome a history of sudden pain associated with violent exercise followed by a latent asymptomatic period and subsequent pain and disability is obtained. Examination reveals flexion contracture of the thigh with adduction and external rotation. There are scoliosis of the lumbar vertebrae away from the affected side and apparent shortening of the leg on the affected side. A mass or fulness is found in the flank, abdomen, iliac fossa or infrainguinal region. A normal outline of the psoas muscle is seen on roentgenograms, and lateral deviation of the upper third of the ureter and the lower pole of the kidney on retrograde pyelography is noted. Irritation of nerves is found in acute large hemorrhagic extravasations, with complete recovery following adequate drainage. Complications of hemorrhage in the psoas muscle include formation of cysts, calcification and infection. Occasionally abscesses of the psoas muscle may perforate into perinephric and peritoneal spaces and contiguous bowel. If the abscess descends to the level of the lesser trochanter, bursitis, synovitis or subcutaneous abscess may result. The syndrome should be differentiated from perinephritis, coxitis, osteomyelitis of a vertebra or of the femur, primary psoitis and intra-abdominal abscess. Early operation results in recovery and no permanent disability."

Wounds.—*Superficial Wounds.*—Abrasions, lacerated wounds and incised wounds are treated along the general lines laid down in the chapter on open wounds. In the case of puncture wounds one must observe the same degree of judgment as to whether or not to administer tetanus antitoxin as applied elsewhere. (See the sections on wounds.)

Penetrating wounds are those which involve not only the external skin but also some underlying organ. In the chest the pleural cavity may be invaded. If the offending weapon is a small sharp knife and does not damage appreciably the lung substance, the wound will close on its withdrawal and no great harm will be done.

Chest Injuries.—In all chest injuries it is important to determine the presence or absence of *pneumothorax*. If pneumothorax is present it is desirable to know if it is of the closed or open variety. When the wound is such that there is a direct path from the pleural cavity to the exterior, the resulting pneumothorax is called an *open pneumothorax*. In a *closed pneumothorax* the air has entered the pleural cavity through a tear in the lung or through an external wound which has become closed. According to Bettman,[17] whose writings on chest injuries are very clear and valuable, the effects of an open pneumothorax are: "First, a collapse of the lungs with a

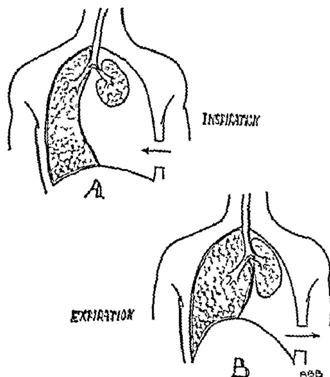


Fig. 173.—Diagrammatic drawing. Mechanism of respiration in case of open pneumothorax. *A*, In inspiration homolateral lung has been able to collapse because air can be sucked through in opening. Contralateral lung collapsing almost to the same degree because the mediastinum can be sucked over. *B*, At the end of forced expiration, compression on contralateral lung, by chest wall and diaphragm forces air out of bronchi, pushes over mediastinum. Reduction of size of chest forces air out through opening. Some air is forced from contralateral lung into homolateral lung. Diagram shows reason for sucking sound at wound, for diminution in aerating surface of lung, for violent mediastinal swinging and also mechanism of so-called "pendelluft." (Bettman, R. B.: Am. J. Surg. 6: 449, 1929.)

marked diminution of the amount of air gaining access to the alveoli of the lungs; second, violent inspiratory and expiratory efforts on the part of the patient; third, a further reduction of available air because of the interchange of air from the so-called 'sound lung' to the lung on the injured side; and fourth, a violent swinging back and forth of the mediastinum (Fig. 173).

"The patient is usually a pitiable sight, cyanotic because of the lack of oxygen, making tremendous respiratory efforts to overcome the diminution of absorption area in the lung, and frequently in shock because of the sudden shifting of the mediastinum with its vital organs.

"If the wound of the pleura can be closed by pulling the skin margins

together, or by means of a wet towel, or even by means of the palm of the hand, the entire picture may change within a few seconds in a most startling manner. The easiest and most readily available material at hand to close the chest wound is the margin of the wound itself. If one margin of the wound can be pulled over the other, the following changes occur. The next inspiratory effort causes suction as before. Now, however, no air, or but very little air, can be pulled in through the chest wound but all or most of the air comes in through the trachea. Thus the lungs themselves will receive as much air as is required to fill the increase in the intrathoracic cavity,

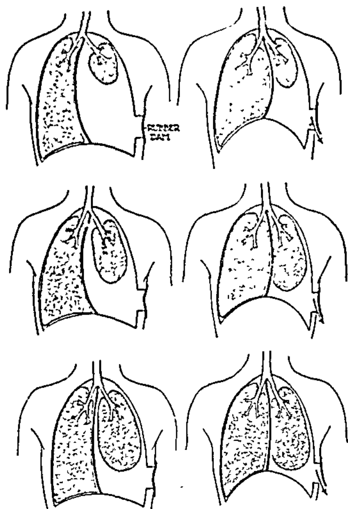


Fig. 174.—Mechanism of treating open pneumothorax. Inspiratory efforts pull rubber dam firmly to chest wall. Expiratory efforts allow air to escape from chest wall. After the completion of a comparatively few respiratory cycles, pneumothorax has been practically overcome. (Bettman, R. B.: Am. J. Surg. 6: 449, 1929.)

brought about by the violent inspiratory effort. The next expiratory movement forces air not only out of the lung through the trachea, but also out of the pleural cavity because if lightly held together the upper margin of the wound will act as a valve flap which is lifted as air is pushed out and shut as air is sucked in. The lung on the injured side and also the contralateral lung will be expanded still more during the next inspiration. and during the next expiration still more of the air in the pleura will be forced out. Thus after but a few respiratory cycles the pneumothorax may be almost entirely overcome, and the lungs practically completely expanded (see Fig. 174). As

soon as sufficient aeration occurs the cyanosis disappears. With the disappearance of the carbon dioxide stimulation, respiration becomes easier and more normal, and with the obliteration of the mediastinal flutter the patient frequently recovers from shock. In a few moments the picture presented by the wounded individual has changed from that of a person apparently or actually gasping his last, to one whose appearance is no worse than if the trauma had been received in some other part of the body.

"Our first cardinal rule in the treatment of injuries to the chest is: Immediately close any sucking wound in the chest."

In closed pneumothorax "the lung on the injured side will be partially collapsed, the mediastinum will be sucked over and the lung on the opposite side also collapsed. However, the next inspiratory effort will enlarge the intrathoracic cavity, which as before will result in a sucking in of air to fill the newly made space. In the case of a closed pneumothorax, however, none of the air will be pulled into the pleural space, but all of it will come into the lungs from the trachea. . . . The amount of dyspnea produced by a closed pneumothorax depends chiefly on how much air has entered the pleural cavity and as a result, how much the lungs have collapsed. . . . By inserting a needle into the pleural cavity and aspirating air the size of the closed pneumothorax can be reduced.

"Thus another rule of treatment can be laid down. In the case of a closed pneumothorax, if the injured patient is in extreme dyspnea because of marked reduction in his vital capacity, air can be aspirated from the pleural cavity, expanding the lungs and increasing his available aerating surface. This should be done only if absolutely necessary because expanding the injured lung may result in an increase in bleeding and in the development of still another type of pneumothorax."

In cases of *internal open pneumothorax*, the wound in the lung gapes as the lung is expanded during inspiration, and air is drawn into the pleural cavity. "With the next expiratory effort the pressure on the lung closes the lung wound, and the pleural air cannot escape. The following inspiration reopens the wound and draws still more air into the pleural cavity allowing the lungs still further to collapse and at expiration again no air is forced out. More air and more air is thus gathered in the pleura on the side of the injured lung. The injured lung is collapsed more and more, the mediastinum can be sucked more and more to the opposite side allowing collapse of the opposite lung. There is less and less available air space. The anoxemia increases with the increase of the carbon dioxide tension. Deeper and deeper inspiratory efforts are made with the result that the pneumothorax is still further increased. Eventually the intrapleural pressure is actually positive except for a short period at the very height of inspiration. When this happens both lungs will be almost fully collapsed even at the end of inspiration and the patient will die of suffocation (Fig. 175).

"The treatment is obvious. The air sucked into the pleural space during inspiration must be allowed to escape during expiration. This can be accomplished by making an opening in the chest wall as follows:

"If the case is first seen in the hospital, the thoracotomy can be carefully performed, a large sized rubber tube can be inserted into the pleural cavity and the external opening of the drainage tube closed by a water valve made by attaching the drainage tube to a long tube which is dropped into a jar

filled with water. In this way air will be forced out of the chest during expiration but during inspiration fluid will be sucked up into the tubing. If the water level is several feet below the lung wound a negative pressure many times that produced by a deep inspiration is necessary to suck the water up to the chest cavity. However, to avoid any danger from such a contingency, the jar used is sterile and a mildly antiseptic solution is used instead of water. If no tubing is at hand it is still possible to overcome the internal pressure

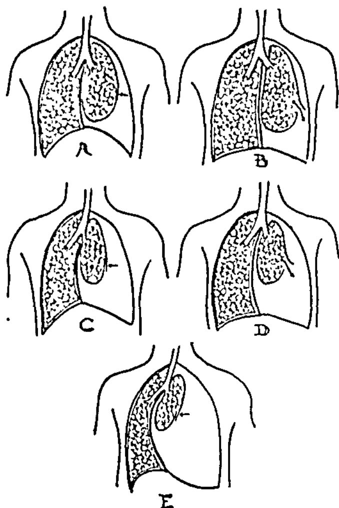


Fig. 175.—Mechanism of internal pneumothorax with valve action due to lung wound. *A*, Pneumothorax lung wound closed. *B*, End of deep inspiration shows lung wound open by increased negative pressure with increase in amount of air in pleural space. *C*, End of inspiration, lung wound is closed. Pleural air cannot escape. Shifting of mediastinum; collapse of contralateral lung. *D*, End of next inspiration. Lung wound reopened, still more air permitted in pleural space. *E*, End of inspiration. Lung wound closed. More pleural air improvised with greater shifting of mediastinum and collapse of contralateral lung. (Bettman, R. B.: Am. J. Surg. 6: 449, 1929.)

pneumothorax by making a stab wound in the chest and then forming a flap, by pulling one wound margin over the other, as described under treatment of open pneumothorax. After the first shock has been overcome the chest cavity should be opened and explored and the lung wound sutured.

"A third rule in the treatment of thoracic cases can be formulated as follows:

"In the presence of marked dyspnea associated with violent respiratory

efforts ascertain the intrapleural pressure either by means of a manometer or by inserting a hollow needle into the chest wall and seeing whether air is sucked in or forced out. If an actual or relative positive pressure internal pneumothorax exists allow for the escape of the pleural air.

"Hemorrhage is another cause of death from injuries to the thorax. The *most usual source of hemorrhage which can be controlled is from the intercostal vessels.* This applies particularly to perforating wounds and to injuries which have caused fractured ribs. Whenever there is an open wound with signs of hemorrhage, bleeding from the intercostal vessels must be suspected. The intercostal vessels are fairly inaccessible, but can be easily compressed by passing a ligature completely around the rib. Thus one might almost be permitted to lay down another rule, to wit: If bleeding is severe after a wound *of the chest wall, the intercostal vessels above and below the wound should* be controlled by passing ligatures around the ribs both posteriorly and anteriorly to the wound.

"When the symptoms from bleeding are not marked, and apparently no other intrathoracic lesion has occurred, it may be advisable to practice watchful waiting. Frequently after a certain time no more bleeding will occur into the pleural cavity. In this case, the question arises whether or not to aspirate the blood. In my opinion, where this can be done with an exacting aseptic technic, it is preferable to remove the blood than to let it absorb. No attempt, however, should be made to do this within the first forty-eight hours, lest, as a result of the procedure, the hemorrhage recurs." (Bettman.)

Head[18] has thoughtfully studied the problem of *hemorrhage into the pleural cavity* and has concluded: "1. When bleeding takes place into the pleural cavity the cardiorespiratory mechanism is attacked from two angles. 2. The effects of decreased blood volume are supplemented by those of high intrapleural pressure. 3. Both of these act to decrease the cardiac output and to compromise tissue respiration. 4. One of the constant effects of high intrapleural pressure is an exaggeration of the respiratory waves of the blood pressure. 5. If the blood pressure is lowered by hemorrhage the further fall during *inspiration may lower the mean pressure below the critical level.* 6. Because the two conditions supplement each other, the patient's symptoms, both respiratory and circulatory, may be relieved by either increasing the blood volume or decreasing the intrapleural pressure. 7. The predominance of circulatory or respiratory symptoms depends upon the relative amounts of blood and air in the pleural cavity. 8. Because the falling blood pressure and the rising pressure in the pleural cavity act to stop the hemorrhage, treatment should be expectant until either circulatory or respiratory signs and symptoms indicate danger. [illegible] air or blood from the pleural cavity should then be [illegible] in the pleural cavity does not clot and rarely becomes [illegible] e escaped blood is suggested as a reasonable form of treatment."

Foster and Prey[19] say the treatment of choice in cases of acute massive *hemothorax is immediate aspiration of the hemothorax followed by injection* of air. Where there is a moderate amount of blood in the pleural cavity, recovery will follow expectant treatment or aspiration and air replacement, but the latter treatment shortens the convalescence.

Duval[20] found that 50 per cent of all patients with fatal war wounds of the lung died during the first day. Lilienthal thinks it not unlikely that this high death rate may be the result of the pressure disturbances incidental to *open pneumothorax.* The first-aid treatment of a sucking wound is closure of the wound by suture, the closure of the skin with adhesive straps or the application of an occlusive wet dressing.[21]

Penetrating wounds of the chest may enter the pericardial cavity with or without wounding the heart. The treatment of such wounds belongs to the realm of major surgery.

Strains and Sprains of the Back. (See also Spondylolisthesis, Sciatica.)—The examination of the injured back should be conducted in a methodical manner. A very valuable guide to such an examination is that of Dr. R. C. Webb, Chief Surgeon of the Great Northern Railway.[22] The examination of a painful back, particularly the lower portion, is difficult and time consuming. All who wish to master this subject should thoroughly study the classic article by Smith-Petersen.[23] Of interest and value is also the paper by Ellis.[24] In any consideration of the differential diagnosis of back injuries, it is well to bear in mind all the causes of lame back. For this purpose the following classification given by Ober[25] is useful.

"1. Arthritis (degenerative):
- Disturbances of metabolism.
- Disturbance of posture.

"2. Trauma (industry):
- Mild trauma, sprains, etc.
- Attitudes at work.
- Fractures, transverse processes, compression.
- Functional neuroses.

"3. Static or postural condition:
- So-called 'epiphysitis.'
- Round shoulders, dorsal or dorso-lumbar kyphosis
- Lumbar lordosis, potential spondylolisthesis.
- Functional scoliosis, short leg, low and prominent abdomens
- Foot strains.

"4 Congenital anomalies:
- Wedge-shaped vertebrae.
- Extra ribs, rudimentary ribs
- Extra lumbar vertebrae.
- Spondylolisthesis.
- Sacralized transverse processes.
- Lumbarized sacral body.

"5. Malignant disease:
- Carcinoma of the bone.
- Sarcoma.
- Tumors of the cord.

"6. Diseases of the abdominal viscera:
- Ptosis.
- Stomach ulcers.
- Pelvic organs.
- Uterus, prostate, and bladder.
- Kidneys.

"7. Unknown lesions (proliferative, infectious)."

Sprains of the back *are caused by overstretching of the intervertebral* ligaments and of the back muscles. They are caused by being thrown from a horse, diving, football injuries, etc. Gilcreest[26] has reviewed 150 cases of pain in the lower part of the back and has concluded that arthritis *per se* was not an important factor in the production of the pain or disability. In the majority of his cases the cause was trauma, and the manner of the application of the force rather than its degree was the important etiologic factor.

Reference should be made to the interesting paper by Albee and Campos,[27] whose summary is as follows:

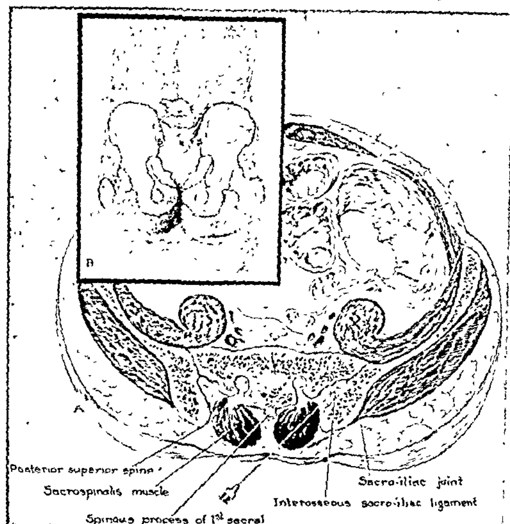


Fig. 176.—Procaine injection of the sacroiliac joint in the diagnosis of sacroiliac strain The patient is placed in the prone position on a table and the sacral region is prepared. It is our practice to administer orally three grains of sodium amytal at this time to prevent any possible reaction from the procaine. About 20 to 30 cc. of 1 per cent procaine is injected. In cases of bilateral sacroiliac strain, 15 or 20 cc. of the solution may be injected into each side. Anatomical studies have shown us that the best approach to the sacroiliac joint requires the insertion of a long (spinal-puncture) needle at a point over the sacrum midway between the two posterior superior spines of the ilia. The needle is then directed toward the desired side, so as to make an angle of 45 degrees with the skin. At this angle, the needle will pass between the lateral portion of the sacrum and the overhanging posterior superior iliac spine, through the fibers of the interosseous sacroiliac ligament to the posterior margin of the sacroiliac joint. The procaine is slowly injected while the needle is being inserted. After encountering bony resistance, the needle is partially withdrawn and reinserted several times, so as to obtain a fan-shaped area of infiltration along the posterior aspect of the sacroiliac joint. A word of caution seems advisable: The needle should not be inserted at such an angle that it will pass superiorly to the upper margin of the sacrum, as it might cause damage in this region. This approach to the sacroiliac joint becomes apparent if one studies a mounted skeleton After waiting five or ten minutes for local anesthesia to take place, the examiner carries out the manipulation of the sacroiliac joints. Such manipulations include straight-leg raising, hyperextension of the hip with the knee flexed and the patient in the prone position, sudden traction on one leg while the other is fixed, and the method whereby one shoulder is pressed against the table and the pelvis on the same side is rotated forward as far as possible, the patient being in the supine position. It is usually found that straight-leg raising, which is limited and painful before injection, becomes normal or much improved under local anesthesia. Likewise the patient can flex the spine forward much farther after the injection. The lower back is then strapped with adhesive tape, and

"Myofascitis is a common condition due to a low-grade inflammation of the muscles and fasciae. Focal infection is the basic cause with trauma frequently acting as the exciting or aggravating factor. The differential diagnosis is difficult as myofascitis simulates or complicates a wide variety of conditions. Treatment consists of improving the hygiene of the patient and elimination of toxicity by a combination of methods; removal of the source of cause of toxicity, local massage, colonic lavage, stimulating the growth of bacilli acidophilus in the intestinal tract and attention to diet. Local mechanical treatment is also applied when necessary."

Most low back strains may be classified as *lumbosacral* or *sacroiliac strains.* The following quotation from Gilcreest is helpful in the differential diagnosis:

"*Lumbosacral Strains.*—In these the pain is over the fifth lumbar and lumbosacral joint, and this joint resists movements of the spine in all directions. There is tenderness over the fifth lumbar and first sacral vertebrae and in both iliolumbar notches. The tests suggestive of this condition are: (1) Prone thrust in hyperextension test is best carried out by having the patient raise himself up if possible from the table. A sudden thrust over the lumbar region will produce or aggravate the pain in lumbosacral sprains. (2) Forward bending does not reverse the lumbar lordosis in lumbosacral sprains. (3) Nachlas' sign—hyperextension of the thigh with the patient prone and the knee flexed, may produce pain in the lumbosacral joint, suggestive of a lesion there (4) Goldthwait's sign—inability to flex the thigh with the knee extended, does not become positive until the leg has been raised quite high. (5) Patrick's sign—forced abduction of the flexed thigh, elicits no pain.

"*Sacro-iliac Strains.*—In these there is pain over the posterior aspect of the joint which becomes worse at night. If the pain is unilateral it is relieved by sitting on opposite buttock. In extreme cases there may be some swelling of the joint. There may be painful areas over the second, third and fourth sacral vertebrae with radiation down the sciatic nerve The accompanying muscle spasm has a tendency to make the whole spine list, usually to the affected side. The following tests may be found useful: (1) Kernig's sign is positive on the affected side; with the patient lying on his back and the extended leg being flexed as far as possible on his abdomen. A normal leg can be flexed to 100°, while the affected leg can only be flexed through a much lesser range without producing definite pain. When this test is positive, it is suggestive, but not pathognomonic, as it occurs in other conditions where the sciatic nerve is involved. (2) Straight leg raising is usually limited and painful, more on the affected side regardless of the leg tested. The pain is felt in the low back, either in the lumbosacral or sacro-iliac region. The examiner should have one hand under the lumbar region and if the pain is complained of before this portion of the spine begins to move, this reaction suggests a sacro-iliac condition. (3) Compression of the iliac crests and pressure over the pubes may bring on or aggravate the pain in the sacro-iliac joint. (4) Cross leg sitting test increases the pain. (5) Goldthwait's sign is manifested immediately the heel is raised from the bed or table. (6) Patrick's sign is occasionally positive, pain being produced over the sacro-iliac joint. (7) Ober's sign is positive if the fascia lata is contracted. This consists in abducting the extended leg with the knee flexed at right angles and the patient on his side. (8) Ely's sign may be positive in sacro-iliac sprains—forcible flexion of the leg on the thigh causes the pelvis to rise off the table and produces pain."

Spondylolisthesis is subluxation of the fifth lumbar vertebra on the sacrum. The fifth lumbar vertebra generally moves forward, but Johnson[28] calls attention to the fact that it may move backward. A supporting corset will often alleviate the symptoms, but operation is sometimes necessary.[29]

Steindler[30] uses procaine to determine the source of the pain in the differential diagnosis of low back pain. A similar method is employed by Haldeman and Soto-Hall,[31] who found that the injection of procaine into the region of the sacroiliac joint (Fig. 176) "produces anesthesia of this joint, which permits

the patient is instructed [illegible]
of sciatic [illegible]
In a few [illegible]
after one week, usually with additional improvement. (Haldeman, K. O., and Soto-Hall, R.: J. Bone & Joint Surg. 20: 675, 1938.)

stretching of tight ham-string muscles and manipulation of the joint," and thus helps determine whether or not the sacroiliac joint is at fault. Steindler[32] has made an interesting anatomic and clinical study of pain in the lower part of the back.[33] He believes that the large majority of the cases of pain due to mechanical causes are primary ligament strains with demonstrable rupture of the ligament, accompanied by extravasation of blood and subsequent scar formation. Sacroiliac strains involve the sacroiliac and capsular ligaments, while sacrolumbar strains involve the ligaments entering the lumbosacral articulation. The *Gaenslen test* is of value in making the diagnosis of sacroiliac strain or disease. The patient lies supine at the edge of the examining table. The knee of the extremity which is toward the center of the table is drawn up to the chest as far as possible and firmly held there by the patient,



Fig. 177.—The Gaenslen test is helpful in differentiating between sacroiliac and lumbosacral lesions. The sketch shows forcible hyperextension of the left hip, with the pelvis and lumbar spine fixed by means of extreme flexion of the right hip. Pain is generally present in sacroiliac and absent in lumbosacral lesions. (Gaenslen, F. J.: J. A. M. A. 89: 2031, 1927.)

who clasps his hands over it. The surgeon then brings the other extremity down over the edge of the table. If there is marked sacroiliac strain or disease on either side, the patient will experience a sharp pain in the region of the affected sacroiliac joint. In the milder cases the pain is generally felt only when the corresponding extremity is extended. This pain is accentuated as the extremity is gently forced downward (Fig. 177).*

In the treatment of back strain and sprain, rest, heat (diathermy) and gentle massage are often useful. Three to five pound traction with weight and pulley and elevation of the foot of the bed will often relieve the pain. Proper setting-up exercises are a useful prophylactic after the acute pain has subsided. In mild cases, in which the patient is ambulatory, and in severe

* Flexing the thigh with the knee extended will bring about pain on the affected side.[34]

cases as well, strapping of the back with adhesive plaster will be of benefit. This is done by having the patient strip to the waist and seat himself upon a table. The back is then arched in extreme lordosis, and a 3 inch adhesive plaster is applied immediately over the spine, extending from the coccyx to the seventh cervical vertebra. Alternate diagonal overlapping supplementary strips of adhesive tape are then applied (Fig. 178).

Another, and perhaps a better, method is to have the patient lie prone upon the table with pillows under his chest and legs so as to produce the lordosis position and yet have the patient comfortable during the strapping (Fig. 179).

Krida[35] recommends the following method of adhesive strapping for a strain of the lower part of the back (Fig. 180).

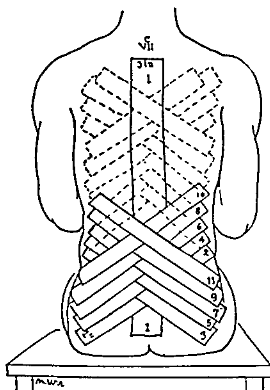


Fig. 178.—Method of applying adhesive straps for a strain of the back. The patient sits in increased lordosis while the adhesive tape is applied. It is often convenient to have him lie prone with the chest and hips elevated (see Fig. 179).

"In order to be effective, the strapping should entirely encircle the lower part of the trunk. It is unsatisfactory in obese patients. The patient stands with the abdomen retracted; the surgeon is seated behind the patient. Three 2-inch strips are applied anteriorly, the lower limit of the dressing extending practically to the level of the trochanters. The posterior strips are then applied. These should extend well forward of the anterior superior spine on both sides, and they should be applied under some tension, as though the effect to be obtained were a compression of the sides of the pelvis."

Ilfeld[36] treats back strain by strapping with the thigh in abduction and external rotation so as to relieve strain on the tensor fasciae latae, gluteus maximus and pyriformis muscles.

Of recent years much more attention has been given to *treatment by manipulation* in cases of sprain of the lower part of the back. It may be useful

in both the acute or chronic types and may be employed without or with an anesthetic. Jostes[37] describes a method, without the induction of anesthesia, which he has used in several hundred cases with

"varying degrees of immediate relief in every instance, and gratifying recovery in the greater percentage of cases. The treatment is selective in type, and its employment is [illegible]

[illegible] latae, marked lordosis, etc.), dislocations (apophyseal subluxation, spondylolisthesis, etc.), fascitis and myofascial syndromes, and sprains (acute or chronic) of traumatic etiology."



Fig. 179.—Prone position for strapping back with adhesive tape. Note the pillow under the chest to increase lordosis.

The patient, unclothed, is placed in the prone position on a suitable mat on the floor. The gluteal muscles are first gently and then more vigorously massaged. The massage then extends from the pelvis up the entire back until the shoulder girdles are included This will help to obtain preliminary relaxation. The greater part of the success of the treatment "depends upon the intelligent cooperation of the patient, since such relaxation at this time is largely self-induced." Jostes employs nine maneuvers. *Maneuvers 1 and 2 may be understood from figures 181 and 182.* An important phase of maneuver 1 "is sudden and prolonged downward and forward thrust to the ilium, which very often results in a snapping sound, at times relatively prolonged, which simulates the tearing apart of sheets of fly paper. This movement tends to shift the left ilium forward or to flex it on the sacrum, separating the posterior margins of the left sacro-iliac joint and therefore tensing

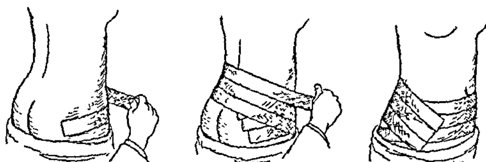


Fig. 180.—Krida method of back strapping. (Krida, A.: Am. J. Surg. 6: 430, 1929.)

[illegible]

and to stretch, therefore, the left anterior sacro-iliac ligaments. . . . Maneuvers [illegible]

[illegible]

lumbar spine and *finally of the hips. With the patient lying prone, the manipulator stands* directly over the patient's pelvis (to protect his own back from strain), grasps the anterior superior spines, and with the patient as fully relaxed as possible raises the patient from the

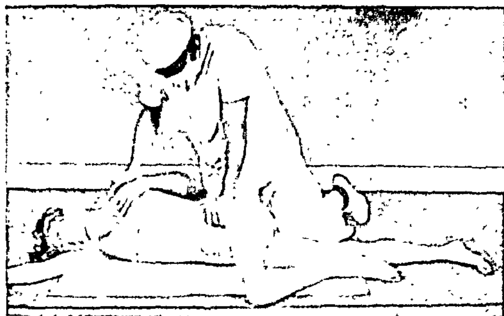


Fig. 181.—Showing the position for Maneuver 1 of the actual manipulation. The ilium is thrust forward and downward; the shoulder is rotated backward. (Flexes left sacroiliac joint and stretches posterior sacroiliac ligament. Some rotary movement to lumbosacral joint.) (Jostes, F. A.: J. Bone & Joint Surg. 20: 990, 1938.)

floor, causing him literally to 'fold up.' While maintaining this position, the operator *rotates the patient's pelvis first to the left and then to the right. If the patient's weight is too* great for the manipulator, this same procedure is carried out using a belt, so that two

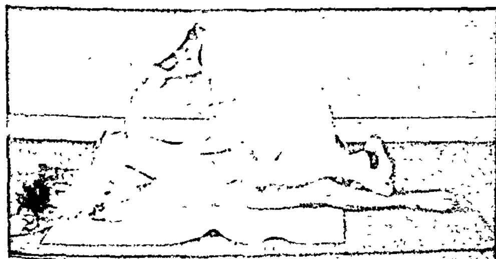
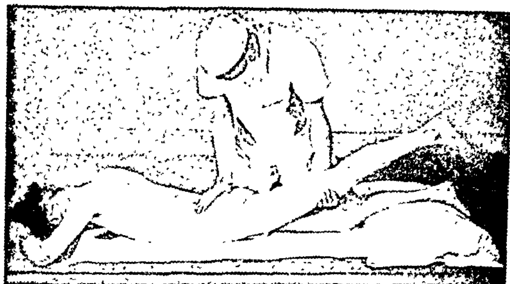


Fig. 182—Maneuver 2—reverse of Maneuver 1. (Extends left sacroiliac joint and stretches anterior sacroiliac ligament; also rotates lumbosacral joint in opposite direction to Maneuver 1.) (Jostes, F. A.: J. Bone and Joint Surg. 20: 990, 1938.)

manipulators carry out the same movements of flexion and rotation as described. This maneuver primarily mobilizes the *lumbosacral joint and the interlaminar articulations,* first by flexion and then by opposing rotary movements. It is especially painful in lumbosacral involvements, although pain is occasionally complained of in cases of sacro-iliac

involvement. Secondarily, the maneuver stretches the contracted sacrospinalis muscles." Maneuver 8 is shown in figure 184, and maneuver 9 is shown in figure 185. (The assistant operator may have to hold down the iliac crest on the affected side.)

"The post-manipulative routine emphasizes the importance of immediate and adequate bed rest; intervals of infra-red therapy and regulated exercises; the proper performance by the patient of routine every-day actions (such as getting up from a chair or sitting



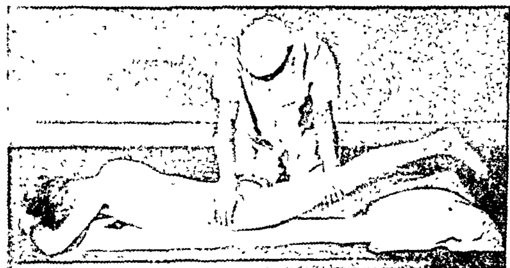


Fig. 183.—Maneuvers 5 and 6—hyperextension of thighs: first with the fulcrum on the ilium; second, with the fulcrum on the sacrum. In many cases, the fulcrum on the sacrum creates much more pain than when it is on the ilium. (Primarily stretches iliotibial bands, secondarily rotates sacroiliac joints clockwise on sacrum.) (Jostes, F. A.: J. Bone & Joint Surg. 20: 990, 1938.)

down, getting in and out of bed, leaning over to pick up an object, and driving his car) which, improperly done, tend to precipitate an acute exacerbation; and finally, in chronic cases, the temporary use of adequate support."[38]

Immobilization in a plaster cast will occasionally be necessary. The symptoms of the acute and chronic inflammatory sacroiliac diseases are more or less the same as those of the traumatic type, although in the former the pain does not start so violently and is seldom referred by the patient

to the region of the synchondrosis. Most of these patients complain of backache and lumbago and often pains of the leg of the same side. Tenderness



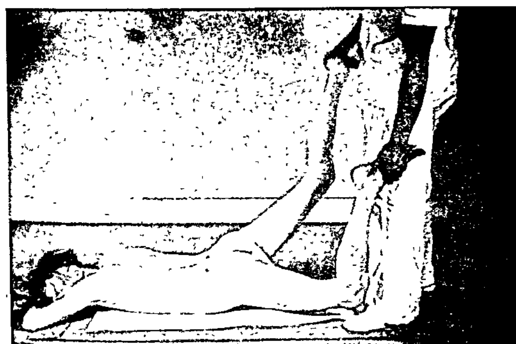


Fig. 184.—Maneuver 8—hyperextension of spine plus rotation of pelvis, first to left and then to right, with spine in hyperextension. (Lumbosacral maneuver, resulting in hyperextension plus rotation of joint.) The legs are likewise moved from left to right, so as to describe an arc in relation to the trunk. Has tendency to efface list by mobilizing lower thoracic and lumbar spine in lateral direction. (Jostes, F. A.: J. Bone & Joint Surg. 20: 990, 1938.)

of the joint on pressure is unusual. *x*-Ray examinations may have some value. The treatment includes external heat, rest in bed, casts, diathermy, massage, exercises and a supporting corset, brace or belt.[39] In all cases of chronic

back pain, search should be made for a focus of infection, and if this is found, it should be corrected.[40]

Sciatica.—Putti[41] describes sciatica as neuralgia caused by pathologic conditions of the intervertebral foramens and articulations. He states that sciatic pain is symptomatic of vertebral arthritis except in those rare cases in which it is a symptom of neuritis of specific nature. According to this author, sciatica is to be considered merely a symptom, and he characterizes as meaningless the term essential sciatica. The chief clinical manifestations of sciatica are pain and rigidity of the lumbar portion of the spine. Jones and Lovett[42] believe that "primary sciatica" is very rare. Ober[43] believes that the iliotibial band "is an exceedingly important factor in the occurrence of lame backs, with or without an associated sciatica." Ober describes his test for a tight iliotibial band as follows: "The patient lies on his side, with



Fig. 185.—Maneuver 9—passive straight-leg raising. (Modification of Baer's technic —counter-clockwise rotary movement of sacroiliac joint) (Jostes, F. A.: J. Bone & Joint Surg. 20: 990, 1938.)

the thigh next to the table flexed enough to obliterate any lumbar lordosis. The upper leg is flexed at a right angle at the knee. The examiner grasps the ankle lightly with one hand and steadies the patient's hip with the other. The upper leg is abducted widely and extended so that the thigh is in line with the body. If there is any abduction contracture, the leg will remain more or less passively abducted, depending upon the shortening of the iliotibial band. This band can be easily felt with the examining fingers between the crest of the ilium and the anterior aspect of the trochanter."[44] He says: "The treatment of this condition resolves itself into one factor, and that is the relief of the contracture. In those cases in which there is no sciatica or other pain, the low back pain may be relieved by stretching exercises carried out in the following manner: The patient stands with the affected side about 2½ feet away from a table or some other convenient object, which

he grasps with one hand; then, with his shoulder and pelvis in the same plane, he bends the affected hip toward the table as far as he can, his whole figure forming an arc. This position is maintained for a few seconds and then repeated five times the first day and is increased once each day until the exercise is done twenty-five times, twice a day." In 415 cases of lame back and sciatic pain, Ober[45] has divided the fascia lata above the trochanter, with complete relief in 75 per cent of the cases. Ober[46] describes his operation as follows:

"An oblique incision, four to six inches long, is made from the lower edge of the anterior superior spine downward and backward, to a point just above the level of the greater trochanter and just posterior to it. The skin and subcutaneous fascia are separated by clean dissection above, below, and posteriorly, until a strip about two inches in width has been dissected well back over the anterior surface of the gluteus maximus muscle. The fascia is now divided from the anterior superior spine well back over this muscle. The fascia gaps at the incision, and the flaps are dissected off the muscles for about one inch on each side. All intramuscular septa are divided. If there is a positive Ely's sign, the fascia surrounding the sartorius muscle is also divided. All loose tags of fascial tissue must be removed. The length of postoperative time in bed depends on the severity of the back symptoms and the rapidity with which the sciatic pain clears up."

Stretching of the sciatic nerve either with or without anesthesia has been helpful.[47] Freiberg[48] has recently studied the relationship of the piriform muscle to sciatic pain. *The Journal of the American Medical Association* (J. A. M. A. 108: 1545, 1937.) says editorially of Freiberg's work:

"Freiberg has recently reported several important observations on the anatomic relations of the sciatic nerve. The piriformis muscle, he states, is constantly found to have a part of its origin from the capsule of the sacro-iliac joint, and it is the only muscle which bridges that joint. This muscle is in extremely close relationship with the sciatic nerve. The nerve, in fact, is found to penetrate the substance of the muscle in 10 per cent or more of cadavers. Experiments on cadavers show that by the Lasègue maneuver the piriformis is put on the stretch after only a few degrees of straight leg raising through the medium of the biceps femoris muscle and its connection with the great sciatic ligament, from which the piriformis derives a part of its origin. The piriformis may therefore be expected to react by spasm as the result of disease in the sacro-iliac joint because of its partial derivation from the capsular ligament of this joint. It follows that the possibility of direct involvement of the [illegible]

[illegible]

band when ir [illegible]
sign of abduc [illegible]
cannot be cc [illegible]
according to Freiberg it seems justifiable that by means of these relatively simple and safe procedures new hope can be offered to a group of cases heretofore highly refractory to professional intervention. As such a measure, Freiberg's proposal seems to offer a subject worthy of further investigation."

The various possible relationships of the sciatic nerve to the piriformis muscle are beautifully shown by Beaton and Anson.[49]

Hertzler[50] defines sciatica as a painful affection of the sciatic nerve due to conditions within the nerve itself, produced by causes unknown or by irritating lesions adjacent to the nerve, and persisting after the subsidence of those conditions. Pain in the sciatic nerve, according to this author, which is the result of some demonstrable organic disease, should not be classified as sciatica. Hertzler injects the nerves where it crosses the neck of the femur with 1 ounce of a 1 per cent solution of quinine urea hydrochloride, with excellent results.[51]

Osteochondritis of the Vertebrae.—This is a destructive disease of the spinal epiphyses found in early youth, the first complaint being of round shoulders or pain. Untreated patients may develop kyphosis. According to Harbin and Zollinger,[52] osteochondritis of the vertebrae may occur in early adolescence. The vertebral bodies become mottled, irregular and wedge-shaped and may be almost completely lost. Round shoulders and an increased dorsal curve rather than pain play a prominent part in the symptoms in some cases.

Harbin and Zollinger[52] say: "During the early period of the disease when pain is complained of, absolute physiologic rest is indicated. The child should be placed upon a Bradford frame with angulation of 20 to 35 degrees. The apex of the curve of the spine should rest at the maximum angulation of the frame, thus maintaining the spine in moderate hyperextension. When all muscle spasm has subsided, the patient may be allowed up, either with a plaster jacket or a spring back brace. Sleeping upon the hyperextended frame should be continued until all deformity has been corrected and the brace removed when roentgenograms show a uniform density and outline of the individual vertebrae. Those patients who present no complaint other than deformity require a period of recumbency upon a hyperextended Bradford frame for several hours daily. This should be continued until the maximum correction is obtained.

"Corrective exercises should be directed toward hyperextension of the spine, in such a manner as to restore the normal physiologic curves. They should always be started immediately following subsidence of pain in the acute cases; such patients as present only deformity should begin the exercises at once.

"When there is a lateral curve combined with an exaggerated anterior posterior curve, the exercises should be of a more specialized character. The general posture of the individual should be considered at all times."

Kleinberg[53] has found epiphysitis to exist in the lumbar portion of the spine. Burman *et al.*[54] report a case involving the symphysis pubis. Pickett and Harbin[55] urge the necessity of prolonged avoidance of weight bearing in certain types of this disease.

Ischiopubic Osteochondritis.—Five cases of this condition have been reported by Durham.[56] The average age was seven and one-half years. The symptoms were principally limitation of motion of the hip and tenderness along the pubic ramus. The treatment consisted of recumbency and traction on the affected hip.

Epiphysitis of the Ischial Tuberosity.—A case of epiphysitis of the ischial tuberosity is reported by McMaster.[57]

Fractures Involving the Trunk.—*The Spine.*—There are many types of fractures involving the spine which may properly be considered as belonging to the field of minor surgery. The majority of fractures of the spine without cord symptoms are minor surgical problems.

In cases of suspected fracture of the spine the first-aid treatment will be the careful transportation of the patient to the hospital provided he is not so badly shocked that the removal has to be deferred. The same great care in transportation so as to minimize movements of the affected parts will be observed as has been described previously. As R. Watson Jones[58] says, "face-down transportation is essential in first-aid treatment." The spine should be kept in hyperextension even during lifting.[59]

Compression fractures (*crushing fractures*) of the bodies of the vertebrae without cord symptoms are of very common occurrence and formerly were often overlooked in the absence of proper *x*-ray examinations. Even today, compression fractures often are unrecognized. Davis[60] has carefully described blood vessel markings on dorsal vertebrae which simulate fractures. Mensor[61]

describes in detail injuries of the accessory processes of the spinal vertebrae and their roentgenographic recognition.[62] In a series of 52 compression fractures of the body of the vertebrae, Stewart[63] found that 22, or 42 per cent, were unrecognized by those who first attended the patients. Brown and Brown[64] report the case of a compression fracture in a 13 year old girl whose back was hurt on a slide and who went on a hike three hours afterward. These authors note that many patients do not consult a physician until three months after the injury. According to Osgood,[65] compression fractures constitute 40 per cent of all fractures of the spine. According to Boorstein,[66] they make up 45 per cent. In most of the cases the body of only one vertebra is involved. This writer says that in 70 to 80 per cent of

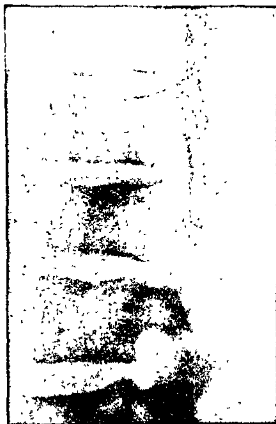


Fig. 186.—Old compression fracture of the twelfth dorsal and first lumbar vertebrae which has been treated by cast and spine brace.

the cases the vertebra involved is the eleventh or twelfth thoracic or the first or second lumbar vertebra. In from 50 to 60 per cent it is the twelfth thoracic or the first lumbar vertebra. Fracture of two or more adjacent vertebral bodies is more or less common. Schneider[67] reported 3 cases of double isolated compression fractures of the spine. The vertebrae involved were the sixth and ninth, the fifth and tenth, the sixth, seventh and eleventh dorsal vertebrae, respectively. Any violent force which causes a sudden forcible hyperflexion of the spine may cause a compression fracture of the body of a vertebra: A fall from a height in a sitting position so as to strike the buttocks, a fall from a horse which causes the patient to strike on his head and forcibly flex the spine and accidents in coasting in which a child on a sled strikes head-on into a tree are particularly prone to cause these

fractures. A slight degree of injury may cause a compression fracture. Verneuil[68] reported a case of compression fracture due to muscular action in a patient who made a successful attempt to escape a fall on the ice.

In 43.1 per cent of 51 cases of psychiatric disorders in which metrazol was used to produce convulsions, Polatin and his colleagues[69] found compression fractures of the vertebrae. In cases of neglected compression fractures of the bodies of the vertebrae spondylitis traumatica tarda or *Kümmell's disease* may occur. This may come as late as months or years after the injury and is *accompanied by increasing kyphosis and pain localized in the injured area* and radiating down the extremities. The original injury may be trivial or it may be severe, but characteristically there is a latent period in which the patient seems to be entirely recovered from the injury only to have a recurrence of the symptoms. The lateral *x*-ray view shows a triangular-shaped body the apex of which is pointed anteriorly (Fig. 186). According to Cardis, Walker and Oliver,[70] there are two chief theories as to the basic pathology of Kümmell's disease. According to one, it is a collapse of the vertebral bodies following injury to the small vessels, with focal hemorrhages and thromboses. According to the other, it is a trophic disturbance of the vertebral bodies due to injury to the nerves and the cord.[71]

Feaster[72] stresses the importance of *x*-ray examination from ten days to three weeks after the injury. He shows films taken immediately after the injury, when the spine looked normal; but films taken twenty-four days later showed a definite compression fracture. This author says the lesion "may exist from five to seven vertebrae above the site of the pain." Osgood cautions the surgeon to look for a tarsal fracture in cases of fractures sustained by falls. Speed,[73] in his excellent discussion of fractures of the spine, shows graphically the mechanism and result of fractures of the corpus vertebrae (Fig. 187). Mitchell[74] calls attention to isolated fractures of the articular processes of the lumbar vertebrae.

The diagnosis of compression fracture of the spine is based upon the history of injury of the proper type, upon the presence of localized pain, and upon the *x*-ray examination, particularly the lateral view, which is absolutely essential. The "*Soto-Hall sign*" is important. Soto-Hall and Haldeman[75] found that this sign was present in 100 per cent of 58 consecutive cases of compression fractures of the spine. It is also present in some cases of severe back sprain, in the active stage of vertebral tuberculosis and in some cases of tumors. They describe the test as follows:

> "*Although it is exceedingly simple, results can be obtained only if every detail of its* technique is observed. The patient is placed flat on his back without pillows, the examiner places one hand upon the sternum of the patient exerting a slight pressure so that no flexion can take place either at the lumbar or dorsal regions of the spine; at the same time the examiner's other hand is placed under the occiput and with this hand the head is bent upon the neck, then slowly but forcibly, the head and neck are flexed upon the [illegible] (Fig. 188). This [illegible] progressive pull upon the posterior spinous ligaments, [illegible] transmitted downward to the interspinous [illegible] of the injured vertebrae. On this it acts as a lever gently compressing the body and producing pain which the patient localizes very accurately."

The majority of compression fractures are not accompanied by injury to the spinal cord. Those causing cord symptoms belong to the province of major surgery.

A patient suspected of having a spinal injury should be transported face downward with the back in lordosis, and utmost gentleness should be used in handling him. As Rogers[76] says:

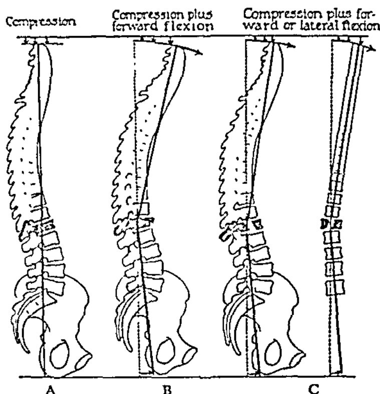


Fig. 187.—Mechanism and result of fractures of the corpus vertebrae. Adapted from roentgenologic tracings. *A*, Pure compression fracture from violence received in long axis of spine without flexion. On lateral view the crushed corpus is narrowed quite uniformly compared to its neighbors; the posterior height is lessened yet equal to the anterior; the intervertebral spaces remain equal. The density of the bone may be increased from the intermeshing of cancellous tissue and the normal longitudinal axis of the spine may not be disturbed at all. *B*, Flexion fracture with a minor degree of compression. The anterior superior edge of the corpus is broken off; the fragment is displaced slightly forward; the posterior height of the corpus is normal and the intervertebral spaces usually remain equal to those adjacent. The main portion of the body does not change bone density. The superincumbent portion of the spine is flexed forward to a varying degree, and there is a cor- [illegible] and displacement of fragments. There may be a typical lessening of height of the body, fracture of the facets and pedicles and more evidence of cord pressure. Some spines when they are viewed in the anteroposterior plane show lateral axis deviation of the superincumbent portion and the corpus may be correspondingly lowered in height on one side compared to the other.

Obviously, types *A* and *C* require more care, greater traction and a longer freedom from weight-bearing to restore the volume and integrity of the corpus vertebrae. Type *B* as a rule offers a better prognosis and a much shorter convalescence. (Speed, K.: Ann. Surg. 102: 102, 1935.)

"The keynote of successful reduction is complete hyperextension of the vertebral column By this means the compressed fragments of the crushed body are drawn into normal relationship by the pull of the longitudinal ligament. The torn ends of the posterior ligaments are approximated. Anything short of complete hyperextension will fail to effect reduction. It is the last few degrees of hyperextension which actually produce reduction."

The experiments on cadavers performed by Davis[77] showed that the tensile strength of the anterior longitudinal ligament of the spine was far more than sufficient to effect reduction by hyperextension.



Fig. 188.—Soto-Hall test for compression fracture of the spine. Flexion of the cervical portion of the spine produces pain at the site of the injury. (Soto-Hall, R., and Haldeman, K. O.: Surg., Gynec. & Obst. 61: 827, 1935.)

Reduction of the compression fracture should be obtained by one of several methods. If the patient is debilitated, the reduction may be produced by gradually increasing hyperextension over two to ten days with the patient supine by the use of the Rogers[78] extension frame bed (Fig. 189). By means of this frame the bed is gradually arched up until adequate hyperextension is

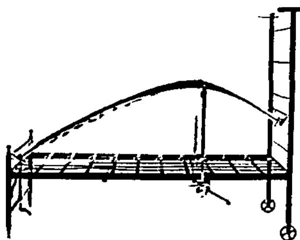


Fig. 189.—Frame A. The ends have been gradually lowered, rendering the frame convex. The spine is extended in this way. This is the simplest and cheapest form of extension frame described by Rogers. It fits the usual hospital bed and is easily made. (Rogers, W. A.: Surg., Gynec. & Obst. 50: 101, 1930.)

obtained. Increasing amounts of padding placed beneath the back and elevation of the back by turnbuckle suspension are useful methods of obtaining hyperextension.[79]

When possible, rapid reduction is preferable to slow reduction.[80] A general anesthetic is difficult to give and is not without some danger. Avertin or

morphine and scopolamine are usually adequate. Local anesthesia is occasionally of value.[81] A lumbar puncture needle is inserted at a point 6 cm. from the apophysis of the injured vertebra (to the right if the patient lies on the right, to the left if he lies on the left side) on a line perpendicular to the vertebral column, and introduced at an angle of 35 degrees toward the fractured vertebrae, and 5 cc. of a 1 per cent solution of procaine hydrochloride is injected directly into the hematoma of the fractured focus. If the needle is bloody when withdrawn, it indicates that the hematoma was located, and an additional 5 cc. of the procaine solution is injected in the same spot; if it is not bloody, one must try again to locate the hematoma.[82]

Rogers says: "The problem of reduction in the lumbar region is very much easier than in the dorsal. A fracture three days old in any region can be more easily corrected than one unreduced for a week or longer. Fractures involving the posterior wall of the centrum require powerful traction during extension so that the posterior fragments will not be pushed backward against the cord or nerve roots during reduction. The reduction of vertebral dislocation is always dangerous and requires a special and sometimes elaborate technique. Therefore, each fracture should be carefully analyzed with these points in mind and the method selected so as to meet the requirements of the individual case."

In simple crush fractures of the lumbar or eleventh or twelfth dorsal vertebra, if no dislocation is present and the posterior wall of the body is not involved, the hammock method is suitable. This is described by Rogers as follows:

"The patient is placed prone upon a flat canvas hammock eight inches wide which has been stretched lengthwise on an ordinary Bradford frame, and which is permitted to sag downward, slowly, until complete spinal hyperextension has been obtained. The sagging of the hammock may be controlled by hand or by a ratchet device at one end of the frame. . . . (The same effect may be produced by using a sheet folded lengthwise until about 8 inches wide. Each end is securely fastened to a table so as to be taut when the tables are separated about the length of the patient's torso. Upon the hammock and tables the patient is placed, face downward, the head and arms on the end of one table, the lower extremities upon the other. The torso rests upon the hammock. The head table should be about 1½ feet higher than the other. The hammock is permitted to sag slowly by moving the tables together.)"

The hammock may be omitted and the patient's body allowed to sag between the two tables, the one at the head being higher than the one at the hips (Fig. 190; method of Watson-Jones[83] and of Böhler). A downward thrust over the injured vertebra may help its reduction.

"The limit of extension varies with age, build, posture, hypertrophic changes, etc., and there is no rule by which it may be accurately determined. When the patient begins to complain of aching in the lumbosacral region the operator may be sure that he is at or near full hyperextension. By carrying the extension a little beyond this ache point after several minutes at a less degree of extension, the absolute limit becomes reasonably assured. X-rays are then taken and if the reduction is satisfactory a plaster cast is applied." (Rogers)

When the fracture involves the posterior wall of the body and, according to Rogers, when a simple crush fracture is over a week old, the Davis[84] suspension method is employed. This method is well described by Rogers as follows:

"The patient, relaxed by morphine-scopolamine, and with the trunk covered with stockinet, is placed face down upon the taut canvas as in the hammock method. The ankles are heavily padded with sheet wadding and ankle slings applied over this. A pulley block

and tackle is fastened to the ankle slings, preferably by a spreader. The other pulley block is fixed to a point about 12 inches distal to the feet and high above the frame or table. The lower extremities are gradually raised by means of the block and tackle while the patient retains position on the hammock by firmly grasping the frame or table (Fig. 191). This maneuver is carried out slowly, especially at the start to overcome muscle spasm and with frequent pauses during which cord function may be checked by having the patient

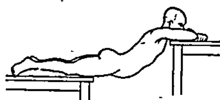


Fig. 190.—Reduction of a compression fracture of the lumbar or 12th or 11th dorsal vertebra by table method. (Watson-Jones, R.: J. Bone & Joint Surg. 20: 567, 1938.)

move the toes. Impending cord pressure during reduction is heralded by motor weakness, nerve root pressure by shooting pains in the lower extremities. Both are preceded by severe pain at the site of fracture. Since a general anesthetic is not used, injury to the cord during reduction can, therefore, be readily avoided. The limit of hyperextension is reached when the pelvis and lower abdomen have been raised several inches above the canvas sling, the thighs make with it an angle of about forty-five degrees and lumbosacral backache

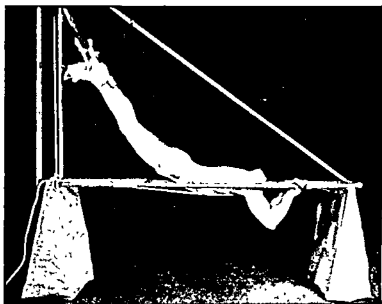


Fig. 191.—The suspension method of obtaining spinal hyperextension combined with traction. The patient is placed face downward upon the hammock. The lower extremities are gradually raised by means of the block and tackle. The surgeon is thus able to extend [illegible]

becomes persistent. The reduction requires but a few minutes. Radiograph may then be [illegible] ension [illegible] fully [illegible] may [illegible] uscle [illegible], still suspended or gentle downward pressure by the surgeon's hands may be necessary to free locked articular processes or disengage impacted fragments. Reduction having been effected,

the traction cord is made to give slightly and at the same time the hammock is loosened until the ventral surface of the entire trunk rests upon the hammock. The felt pieces are then applied, one about the chest, one about the iliac crest, and the third—the thicker—along the spinal column from just above the angles of the scapulae to the mid-sacrum. A

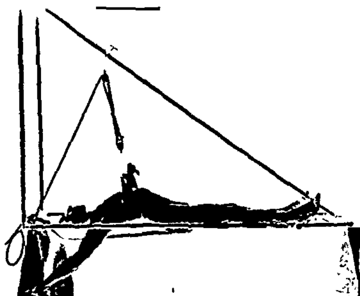


Fig. 192.—The hammock frame adapted to the sling method of obtaining dorsal hyperextension. Reduction is very much more difficult in the upper ten dorsal vertebrae and greater forces are necessary. The same mechanism may be employed with tables. (Rogers, W. A.: Am. J. Surg. 38: 599, 1937.)

plaster jacket is then applied with the patient in suspension. As quickly as this has dried, the traction is released, the canvas hammock cut and withdrawn and the patient returned to bed."

In cases of fracture of the dorsal vertebrae above the eleventh, the sling method of Dunlop (Fig. 192) may be used.

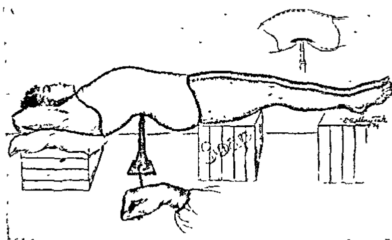


Fig. 193.—Patient supported by apparatus. (Ryerson, E. W.: J. A. M. A. 103: 562, 1934.

Ryerson[85] shows how hyperextension of the spine can be done by use of an automobile jack and soap boxes (Fig. 193). He says: "Two short pieces of $\frac{1}{2}$ inch gas pipe, 2 inches long, are brazed vertically to the top of the jack, about 1 inch apart. Four flat strips of iron measuring $\frac{1}{2}$ by $\frac{1}{8}$ by 4 inches are

bent at the middle to a right angle and two of them are slipped into each gas pipe. This makes two T-shaped supports on which will rest the kyphosis, protected by a thick piece of felt 4 or 5 inches square. The head and shoulders rest on boxes, and the buttocks and legs are similarly supported, padded with pillows or folded blankets." Stockinet undershirt having been previously applied, the jack is elevated until the desired degree of hyperextension is obtained, and the cast is applied. The four small angle irons are easily removed through the hole in the case.

After reduction has been effected and checked roentgenographically, a plaster cast is applied. A broad sheet of ¼ inch felt is placed over the back and tailored to fit the curves of the body. It completely encircles the body at the hips and chest, and the ends are fastened with adhesive plaster. A bandage

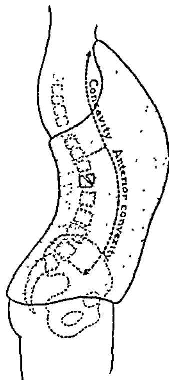


Fig. 194.—Diagram showing the extent of the plaster jacket used in the treatment of lower dorsal and lumbar vertebral fractures. (Rogers, W. A., in Christopher, F.: Textbook of Surgery, ed. 4, Philadelphia, W. B. Saunders Company, 1945, p. 623.)

is placed between the stockinet and the skin so that it may be drawn to and fro as a scratcher. The cast is shaped and finally cut out so that it appears as shown in figure 194. After the cast has dried, the stockinet edges are turned over and fastened down to the cast with adhesive plaster. Roentgenograms are taken after the cast has been applied.

Rogers believes the patient may be ambulatory provided the posterior portion of the vertebra is intact. He prefers to keep the patient recumbent for six weeks, during which time the abdominal and spinal muscles are exercised. In the case of a simple crush the cast may be removed at six weeks, and a Taylor spine brace (Fig. 195) or a composition corset may be worn for four to six months longer when the patient is up. In cases of more severe involvement with damage to the posterior portion of the body of the vertebra

the cast is worn for four or five months. Roentgenograms should be made at six month intervals for several years.[86]

Physiotherapy will be useful in the last weeks of the treatment. Böhler[87] places great stress on the importance of physiotherapy. He says, "When a patient is put to bed in a plaster cast he is rendered both physically and psychically ill. The muscles become weak, the bones lose some of their calcium content, and the vertebral joints become stiff. The author's patients are permitted to walk without a cane on the second or third day after the application of the cast. Twice daily the patients are put through exercises of the arms, bending of the knees, extension of the legs and muscling up of the body on rings. To strengthen the muscles of the back, the body is made to rise from a horizontal to a vertical position. Lifting of the thighs while lying

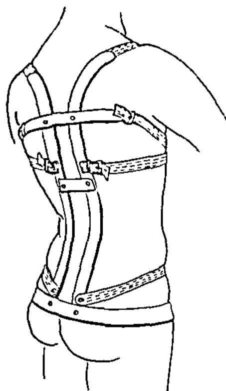


Fig. 195.—Taylor spine brace.

flat on the back develops particularly the iliopsoas muscle, which bears the closest relationship to the fractured vertebrae. Toward the end of the treatment the patients are made to carry a weight on their heads for from twenty to forty minutes. They begin with a weight of from 1 to 2 Kg., which is increased to 50 Kg. Patients treated in this manner are in the best physical and mental condition."

Buerkle-de la Camp[88] finds fewer days of illness and fewer instances of permanent disability in the "functional treatment" than in the "reduction treatment." In the functional treatment the patient is kept recumbent on a thin mattress under which a board is placed. Sand bags are used to effect a gradual reduction of the hump if the gibbus is considerable. During the first two weeks the patient lies on his back but is permitted to lie on a side for short periods. Heat is applied by means of a heating pad. From the third week on heat is applied with the patient in the prone position and the musculature of the back, excluding the region of the fracture, is massaged. With the beginning of the fifth week the

patient is raised to sit up in bed at meal time; this is gradually increased to a regular exercise. After six weeks the patient gets up and is usually able to bend over without *holding the* vertebral column stiff. Gymnastic exercises are begun. The patient is able to work after an average of one hundred and thirteen days. In the less severe injuries the time required for treatment is shorter (from six to seven weeks).[89]

Osgood finds a full return to function in these cases in four to six months. While operation is advocated in these cases by some authors[90] Eikenbarry of Seattle says that "the only patients who were able to go back to hard work were those who were treated conservatively." Christopher[91] reported on 9 patients treated by conservative methods and followed for an average of 27.5 months, with 88.8 per cent excellent or good results and 11.2 per cent fair results. In no case was the result poor.

In an illuminating article Rogers[92] says that 96 per cent of recent fractures of the vertebral body can be corrected so as to reestablish the preinjury mechanics of the back. Sixty-five per cent of his patients returned to preinjury activities in an average of eight and one-third months. He says that reorganization of bone is probably fully adequate in from two to seven months in most cases.

Fractures of the Transverse Processes of the Vertebrae.—Previous to the general use of x-rays, cases in which there was a fracture of a transverse process of a lumbar vertebra were not uncommonly treated as "sprained backs." We now know that such fractures are not rare. They are perhaps more frequent as complications of other injuries and seldom occur alone. In the mining district of Bochum, Magnus[93] found 99 cases of isolated fractures of the transverse process of the vertebra. The first lumbar vertebra was involved 44 times, the second 16 times, the third 18 times, the fourth 11 times, and the fifth twice. These fractures are caused most commonly by direct violence. They may also be caused by the forcible contraction of the psoas and quadratus lumborum and longissimus dorsi muscles, as when lifting a heavy weight when in the flexed forward position or in cranking a motor. (Speed) The author has seen two cases caused by the accidental fall of the door of an automobile trunk compartment while the person was leaning forward into the compartment. The first symptom is generally very acute pain with some localized tenderness. Sitting up or raising the leg when lying on the back is painful.

The symptoms may simulate those referable to the kidneys.[94] The diagnosis is made certain by roentgen study. In interpreting the roentgenogram one should remember that the transverse process of the first lumbar vertebra often shows a joint at its distal end (lumbar rib). Speed[95] calls attention to the early symptom of abdominal pain caused by pressure of the fragments or of a hematoma on the nerve trunks. The treatment of the patient with an isolated fracture of the transverse process of the lumbar vertebra is rest in bed for from seven to twenty-five days, accompanied by heat and massage. Toschi[96] says that the greater number of these fractures can be healed in [illegible] may [illegible] liza- [illegible] ould be careful for two months but should be completely cured in six months. It is extremely important not to let the patient overestimate the seriousness of his case. If he feels that he has a broken back, complete recovery will be

delayed if not indefinitely postponed. In cases in which the fragment is widely separated and nonunion occurs, if pain is a marked symptom the operative removal of the detached fragment should be considered.

Quaintance[97] studied 33 cases of fractures of the transverse processes of the lumbar vertebrae. The transverse processes of the second, third and fourth lumbar vertebrae constituted 85 per cent of the total number of fractures in this series. Temporary disability in the 25 cases uncomplicated by other fractures lasted, on the average, slightly more than ten weeks. The minimum period of disability was zero and the maximum slightly more than seven months. None of his patients was permanently disabled, and in none was the resection of the fractured processes found to be necessary. Quaintance states that "the duration of disability often is influenced as much by the psychic and personality factors and by the provisions of state compensation laws as by the severity of the injury itself, as indicated by physical examination and roentgen observation." Lasher[98] says a fracture of the transverse process may be treated as a sprain of the back muscles.

Fractures of the spinous processes rarely cause serious difficulty, and the patient usually remains at work. Bofinger,[99] who collected reports of 16 cases, believes the cause to be muscle pull. Schnek[100] treats these patients by injecting 5 to 10 cc. of 2 per cent procaine solution. The term "*clay-shoveler's fracture*" is applied to fractures of one or more spinous processes of the lower cervical or upper thoracic vertebrae. Hall,[101] in reporting 15 cases, recommends the early removal of the detached fragment.

Fractures and Contusions of the Coccyx; Dislocation of the Coccyx.—A heavy fall upon a sharp edge, a kick or difficult parturition may bring about injury to the coccyx. This injury may be a contusion or a fracture of the coccyx itself, a rupture of the ligaments which attach the coccyx to the sacrum, or dislocation of the coccyx. Injuries to the coccyx are more common in women than in men. In the late cases in which the fracture has healed in an abnormal position there may be severe pain upon sitting, pain upon defecation and persistent neuralgic pains in the thighs and legs. In all cases of pain and tenderness in the coccygeal region in which injury of the coccyx is suspected, it will be advisable to make a roentgen examination in two planes, the lateral being the more important. Moreover, in all cases in which injury to the coccyx is suspected an examination should be made with the gloved finger in the rectum, and between it and the palpating external finger the presence or absence of crepitation, abnormal mobility or displacement will be elicited (Fig. 196). Extensive ecchymosis of the gluteal regions and upper portion of the thighs is not uncommon.

In recent cases the *treatment* will consist of replacement of the displaced fragment. This procedure is carried out by having one finger in the rectum and the opposite hand on the outside. General anesthesia often will be necessary. After reduction of the deformity has been accomplished, rest in bed for a period of two to three weeks is advisable. In cases of dislocation, in which the dislocation recurs several times after displacement and is accompanied by pain, and in cases of fracture in which there is continued pain and discomfort even after union has occurred or if malunion has obtained, the operative removal of the coccyx is indicated. The operation is carried out through a posterior midline incision, and the coccyx is dissected out and removed from the sacrococcygeal junction. Speed[102] emphasizes the impor-

tance of rigid asepsis and adds that the "relief is due to the severance of the coccygeal nerves or their release from pressure by the misplaced bone."

Coccygodynia, or painful coccyx, is practically always the result of an injury to the coccyx and is rarely of psychic origin. If the cause is a displacement due to fracture or dislocation, reduction should be effected at once. Otherwise, conservative treatment should be persisted in for at least six months. The nonoperative treatment includes hot sitz baths daily, correction of constipation, sitting erect so as to put more pressure on the buttocks, and the use of pillows and a rubber ring. Manipulation and massage of the coccyx are often very helpful. Hobart[103] treated 15 patients by manipulation and cured 8 and relieved 3.[104] In cases of severe chronic coccygodynia, excision of the coccyx should be carried out. Duncan[105] reported 30 excisions of the coccyx. There was complete relief in 22 cases, with partial relief in 3. Five patients were unimproved. The technic of excision of the coccyx is

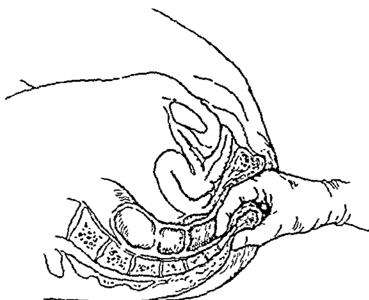


Fig. 196.—Rectal examination and manipulation of coccyx. Patient on left side with knees and hips flexed. Examiner's right index finger in rectum and thumb outside. (Lewin, P.: S. Clin. North America *16*: 113, 1936.)

carefully described by Key,[106] who also bevels off the protruding distal end of the sacrum.

Minor Fractures of the Pelvis.—The pelvis is injured by crushing forces applied in that region, particularly when the patient is squeezed between two cars or when a vehicle passes over the pelvis. It may also be injured by blows, such as being thrown sideways in an automobile accident. The superior rami of the pubes may be broken by a fall on the great trochanters of the femurs. There may be slight displacement of the fragments in these cases, which is usually accompanied by a lesser fracture of the descending ramus (Figs. 197 and 198).

Noland and Conwell[107] say that "the pelvic fractures in women seen during the three years 1920 to 1923 constituted only 10 per cent of the total number of such fractures caused by accidents of civil life, whereas those seen during the five years from 1923 to 1928 constituted almost 50 per cent of such frac-

tures. Seventy-five per cent of the pelvic fractures in women were caused by automobile accidents."



Fig. 197.—Fracture of the pelvis. Note the fracture of both horizontal and descending rami of the pubis.

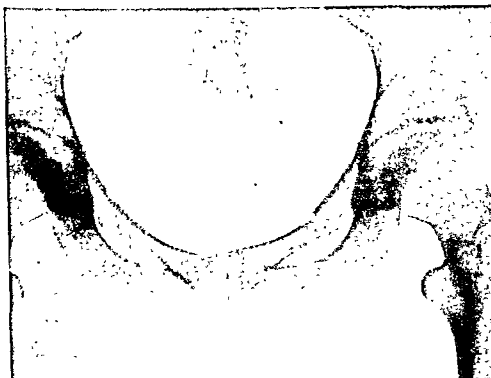


Fig 198.—Fracture of the pelvis shown in the preceding figure after six weeks' rest in dorsal position.

Boorstein[108] says that the diagnosis of fractured pelvis is "comparatively easy if one carefully examines the irregular bones of the pelvis and ilium

both inside and outside. The two ilia should be crowded gently but firmly together to determine crepitus. Vaginal and rectal examination should be *included.*" *The most important* symptom of fracture of the pelvis is pain.

In all cases in which injury to the pelvis is suspected the urine should be examined for the presence of blood, which would indicate laceration of the bladder. If necessary, catheterization should be resorted to in order to obtain a specimen. Failure to recover urine after catheterization indicates rupture of the bladder, and major surgical treatment is indicated. The presence or absence of rupture of the bladder may be determined with certainty roentgenographically after injection of air into the bladder. No fluid should be injected into the bladder if rupture is suspected. A rectal examination should be carefully made in order to search for lacerations of the rectal mucosa. The abdomen should be carefully examined for evidence of intraperitoneal injury. In Wakeley's[109] series of 100 cases of fracture of the pelvis, only 11 (11 per cent) included visceral complications. *x*-Ray examinations in two planes or stereoscopic study is a *sine qua non.* A great many fractures of the pelvis may be classified as minor fractures. In all cases in which there is no injury to the bladder, rectum or peritoneum or in which there is no mobility of the fragments, the injury may be regarded as a minor fracture. Minor fractures of the pelvis may be defined as impacted fractures of the rami of the pubis, linear fractures of the ilium and linear fractures of the sacrum, *without* visceral injury or mobility of the fragments.

The treatment of minor fractures of the pelvis is rest in bed for an adequate length of time. The writer has seen the displaced fragments of a superior ramus fracture perfectly aligned after mere rest in bed. Patients with very minor injuries may be permitted to walk in from two to three weeks. If the fissures are more extensive and are multiple, a rest period of four to six weeks will be required. In a series of 35 cases of fracture of the pelvis Colp and Findlay[110] state that the average length of time following the injury before walking was allowed was thirty-eight days. The patient is *not permitted to sit up in bed* during this time because the pressure upon the tuberosities of the ischia may cause displacement of the fractures. Before permitting the patient to walk, it will be well in all cases to equip him with a Goldthwait belt or a strong supporting girdle which exerts compression on the great trochanters of the femur and upon the iliac crests. These patients are apt for a long time to complain of pain in the back or in other regions of the pelvis. This is treated by external heat, diathermy and massage. The prognosis in cases of minor fractures of the pelvis generally is excellent. Eliason and Johnson[111] reported 60 cases of fracture of the pelvis, with perfect results in 71 per cent, fair to good results in 18 per cent and poor results in 11 per cent.[112]

The treatment generally advised for *separation of the symphysis pubis* is rest in bed with a snug belt or a bandage about the hips. The snug-fitting belt described by Boland[113] will be serviceable. Sarazin[114] has suggested an ingenious treatment for this condition. The hips are swathed in firm canvas or leather bands, the ends on the anterior side interlacing between each other much like those of a scultetus binder. These ends are attached to bars, one on each side, and these two bars in turn are attached to ropes which run upward and outward at an angle of 45 degrees over pulleys. Weights are then placed at the ends of the ropes, and thus continuous compression of

the pelvis is effected. Too much compression, however, may cause a narrowing of the pelvis.

Avulsion fracture of the ischial tuberosity is usually treated by means of rest and local heat, although surgical excision of the fragment may be necessary (Abbate[115]).

Fracture of the anterior superior or anterior inferior spine of the ilium is known as "*sprinter's fracture.*" In this injury a fragment of the bone is pulled off by muscular violence, such as at the start of a race or in kicking. It occurs chiefly in young muscular individuals. Christopher,[116] who collected reports of 24 cases, suggests that the injury is more likely to occur in runners who have not been properly "warmed up" and whose muscles are relatively inelastic. *x*-Ray examination readily reveals the displaced fragment. Gallagher[117] stresses the importance of *x*-ray examination in these cases rather than making a diagnosis of "pulled tendon." Rest in bed for two weeks with restricted use thereafter generally suffices for a cure. Bachmann[118] reports a case of bilateral tearing off of the inferior iliac spines.

Conwell and Alldredge[119] say: "The best treatment is immobilization for four weeks in a plaster hip spica with the thigh flexed on the trunk. Active physical exercises should not be resumed for six months or more. We do not believe that open reduction is indicated in the average case. Even though accurate anatomical reduction is not always accomplished in the closed method, the end results are just as good."[120]

Avulsion of the epiphysis of the tuberosity of the ischium has been reported by MacLeod and Lewin.[121] Cohen[122] reported an "avulsion fracture" of the ischial tuberosity and collected reports of 3 more cases from the literature. He says: "(1) Avulsion fracture of the ischial tuberosity, though uncommon, should always be suspected up to the age of twenty-five, when union generally occurs. (2) Bony union is not necessary for a resumption of [illegible] or in a combination of both, [illegible] a [illegible]-sion. (4) The treatment of choice is conservative,—namely, complete rest in bed with the knee in flexion if much hamstring spasm exists."

Fractures of the Clavicle.—With but few exceptions fractures of the clavicle belong to the field of minor surgery. The exceptions are severe compound fractures of the clavicle, severe comminuted fractures of the clavicle, with nerve pressure, and the very rare cases of nonunion which require an open operation.[123] Some 5 to 10 per cent of all fractures occur in the clavicle. In 10,702 cases of fracture at the Cook County Hospital, Speed[124] found 538 clavicular fractures. Hukewytsch[125] observed 32 fractures of the clavicle in 2213 newborn infants (1.44 per cent). He concludes that many fractures in the newborn are overlooked. Jimeno-Vidal[126] reports on 30 isolated gunshot fractures of the clavicle. Hey Groves[127] states that there is probably no bone the fractures of which are so infrequently accompanied by serious complications or so seldom require operative treatment. Watson-Jones[128] says: "In fractures of the clavicle, especially in patients over the age of forty, there is only one real danger—the danger of stiff fingers and a stiff shoulder. The fear of these complications must dominate the treatment." The clavicle is the earliest bone in the body to ossify, and this may account for the frequency of its fracture in youth. Fracture of the clavicle almost invariably is incurred by a fall or blow upon the shoulder, so that the force is directed medially toward the sternum. Some 6 per cent of fractures of the clavicle are caused by direct violence. Many patients are immediately conscious that they have

broken the collar bone because of the sensation of subjective crepitus and by the abnormal deformity in the clavicular region, due to the tendency of the unsupported shoulder to drop downward, with the resultant prominence of the fragment ends at the fracture. In most cases simple palpation of the clavicle will establish the diagnosis, but a roentgenogram must under no



Fig. 199.—Greenstick fracture of the clavicle.

circumstances be omitted, because it will often reveal comminution or more marked displacement than was suspected (Figs. 199–202). In young infants fractures of the clavicle are very common and frequently are overlooked. The baby may have a fall which is not observed by any one and he will be found whimpering and showing evidences of pain and will exhibit difficulty



Fig. 200.—Complete fracture of the clavicle; good position.

in using the arm on the affected side. The parents' attention will be directed toward the arm, but the existence of a collar bone injury will most often not be suspected by them nor, sad to say, by the physician. Patient and careful palpation of the shoulder will generally elicit a tender spot and often deformity along the clavicle. Movement of the arm is painful. *x*-Ray examination, of

course, never should be withheld. Fractures of the clavicle in elderly persons are frequently accompanied by considerable shock and a great deal of pain. In these cases first-aid treatment should be directed toward pain and shock, and the position of the clavicle should be neglected until these conditions are alleviated.

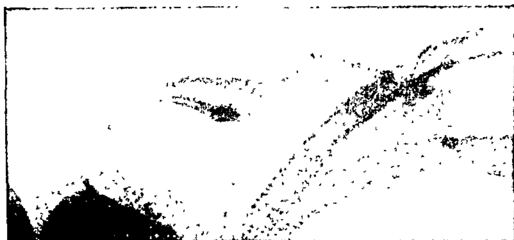


Fig. 201.—Fracture of the clavicle with displacement of the fragments.

As Eliason[129] points out, "incomplete or greenstick fractures can well be handled with a Velpeau or Sayre dressing or any one of their many modifications. These patients require protection for from two to three weeks and a sling only for another week, when recovery is complete."



Fig. 202.—Severe comminuted fracture of the clavicle.

Before the application of any type of ambulatory dressing an attempt may be made to reduce the fracture. This is generally best accomplished by having the patient sit upright and, with his muscular cooperation, drawing both of the shoulders backward. The surgeon's knee may be placed in the middle of the back to make countertraction. Drawing the arm upward and

outward with countertraction on the side of the neck is occasionally useful (Speed). When little assistance is available, McLaughlin[130] advises using the weight of the upper extremity to help obtain and maintain reduction (Fig. 204).

The fundamental principle involved in the *treatment of fractures of the clavicle* is traction. In the absence of traction the pull of the pectoral and

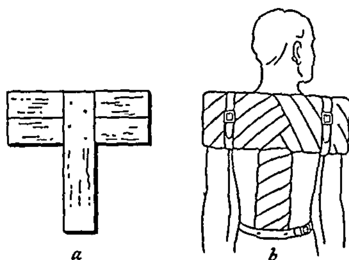


Fig. 203.—*a*, T splint in the rough; *b*, T splint covered with cotton and bandages It is fixed by a pelvic strap to the pelvis and holds the shoulders upward, backward and outward by straps. (Spiers, H. W.: A Brief Outline of the Modern Treatment of Fractures, Baltimore, William Wood & Co.)

scapular muscles and the weight of the arm will drag the shoulder mesially and will cause overriding or upward or downward deformity of the fragments. At least 90 methods of fixation of the clavicle have been published. In 1921 von Mezo[131] collected reports of 85 methods of fixation of fractured clavicles. The writer knows of at least 5 other new methods published since that time.



Fig. 204.—Reduction of fracture when assistance is not available. (McLaughlin, H. L.: S. Clin. North America 20: 549, 1940.)

In the ambulatory treatment, by far the best method of obtaining traction and the consequent proper position of the fragments is the employment of such an apparatus as will hold *both* shoulders *backward and upward.* Various braces have been devised for this purpose. Most of them are modifications of the T splint (Fig. 203). The clavicular cross splint, which is made of aluminum, is well padded with felt, has a vertical piece extending downward

to the waist, has well padded, adjustable straps which pass under both axillas and has a belt, is the most serviceable for adults* (Fig. 205). In infants, very young children and women, an all-leather brace which fits under both shoulders and straps across the scapulas is almost ideal (Fig. 206).† Both of these types of clavicular splint should be put on at first with but slight traction, because the patient may ill adapt himself to the pressure under

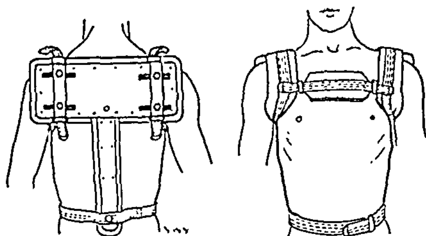


Fig 205.—Aluminum clavicular cross splint. (Zimmer Manufacturing Co., Warsaw, Ind.)

the axilla. After he has worn it loosely for twenty-four hours he will unconsciously acquire the habit of retracting his shoulders to pull away from his braces. The straps will then be tightened, so that the shoulders will be held as far back as possible. The patient will be cautioned to watch for any circulatory disturbance of the arm or for any numbness or tingling pain which may be due to unusual pressure upon the nerves. Inasmuch as the

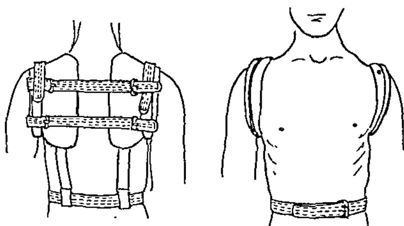


Fig. 206.—Adjustable clavicular brace. (DePuy Splint Co., Warsaw, Ind.)

pull of the braces is directed chiefly backward and not upward, traumatic paralysis (Saturday night paralysis), from pressure upon the brachial plexus, is extremely unlikely. A patient who chafes at the restraint of the braces will more gradually accustom himself to it if he is advised to lie on his back as

* Zimmer Manufacturing Co., Warsaw, Ind. A very serviceable adjustable clavicular cross splint is also made by the DePuy Splint Company, Warsaw, Ind.

† DePuy's splint made by the DePuy Splint Co., Warsaw, Ind.

much as possible for the first few days and to relieve the pressure of the braces by holding his arms akimbo. It is surprising how well these clavicular cross braces and splints are tolerated, and in a very few days the patient will be in a far more comfortable condition than with the old-fashioned Velpeau-Sayre dressings and casts which, moreover, cause limitation of the shoulder joints after removal. Both arms will be free and may be actively used. The patient may wear his clothing, both arms being allowed to go into the sleeves, and encouraged to go about his daily business. In about forty-eight hours young children will be playing as vigorously as they did before the injury, in fact, so zealously that they will have to be restrained. Watson-Jones[132] recommends the figure-of-eight bandage.

"The patient sits on the edge of a stool and the operator stands behind with one foot on the stool and his knee between the patient's shoulder blades (Fig. 207). A large pad



Fig. 207.—Application of figure-of-eight bandage for fracture of the clavicle (Watson-Jones, R.: Fractures and Other Bone and Joint Injuries.)

of wool is placed in front of each shoulder extending into the axilla. Several long bandages 5 or 6 in. wide are now applied in the form of a figure eight, passing in front of the shoulders, under the axillae and crossing between the shoulder blades. With each turn of the bandage the shoulders are pulled upwards and backwards; care must be taken not to apply the bandage so tightly that the axillary vessels are compressed. The turns of bandage are held in position by stitching or strapping them to each other. They should be reapplied every third or fourth day during the first fortnight. The tension of the bandage prevents the outer fragments from displacing forwards, and the weight of the arm acts as a lever over the axillary pad, distracting the outer fragment away from the midline and so correcting the overriding (Fig. 208). For the first week the limb is supported by a triangular sling tied over the opposite shoulder. The finger, wrist and elbow joints must be exercised at regular intervals from the moment of injury." When there is clinical evidence of union, in about three or four weeks, the bandage is discarded.[133]

Goehrs[134] has advised the use of a figure-of-8 piece which is cut to proper size from the inner tube of an automobile tire. Under certain conditions

the writer has found this to be excellent. For fractures of the proximal and middle thirds of the clavicle, Thomson[135] uses a figure-of-8 plaster cast which is applied over a sheet wadding bandage while the arms are held abducted upward and backward. The cast embraces the chest and can be cut out about the neck and arms without weakening. This method is endorsed by Parker[136] and, in more extended form, by Kini.[137] Anderson[138] has advocated a splint which treats the fractured clavicle by suspension and elevation. Murray[139] has treated 29 patients with fractures of the clavicle, in which a satisfactory reduction was not obtained, by open reduction using a Kirschner wire for fixation. (See section on Foreign Bodies.) Skeletal traction, by means of a small wire through the outer end of the clavicle, has been used by Rowe.[140]

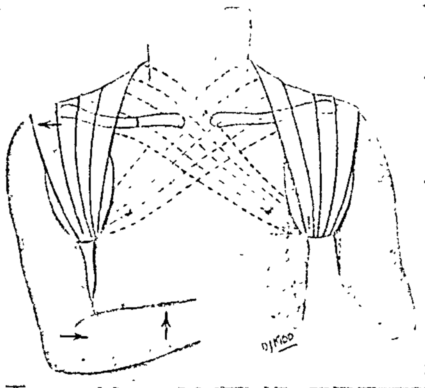


Fig. 208.—The bandage pulls the outer fragment backwards and upwards, and the weight of the arm over the axillary pad maintains distraction from the midline. (Watson-Jones, R.: Fractures and Other Bone and Joint Injuries.)

While plaster casts are considered obsolete by most surgeons in the treatment of fractures of the clavicle, they are still recommended by a few careful workers who believe better restitution of position and positive support are obtained.[141] In elderly persons the amount of exudate and callus thrown out at the site of the fracture may cause a great deal of pain and in some cases stiffness and swelling of the fingers and wrists. The best treatment for this unpleasant complication is heat, massage and elastic traction to the fingers and wrists, and similar physiotherapeutic measures applied to the shoulder.

In infants and very young children the writer prefers the Watson-Jones figure-of-eight bandage or the DePuy splint (Fig. 206). If there is a greenstick fracture with upward bowing of the fragments, it is sometimes wise to

sion of the lung rather than from puncture of the lung by a broken rib. *x*-Ray examination in two or three planes, which must be made with particular attention toward the ribs, will show the injury. In severe cases, as many as nine or ten ribs may be broken on one side. Leavitt[157] reports a case in which there was nonunion of three ribs.

Compere and Banks[158] say: "Injection of 3 cc. of 1 per cent novocain into the hematoma at the site of each fracture before applying adhesive strapping will contribute greatly to the patient's comfort."

Funston[159] recommends for fractured ribs a "fashioned canvas binder with a shoulder strap, similar to the Sam Browne belt" (Fig. 209). The Zimmer* splint is a substantial canvas belt with two shoulder straps for support in rib fractures. Three buckle straps provide for snug adjustment to the contour of the body (Fig. 210).

A satisfactory treatment for fractured ribs is the application of a tight circular muslin bandage around the entire chest rather than strapping with

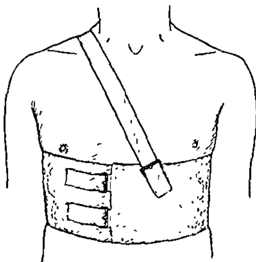


Fig. 209.—"Sam Browne" belt for rib fractures. (Funston, R. V.: J. Bone & Joint Surg. 13: 174, 1931.)

adhesive plaster. This is applied during complete expiration and is put on four or five layers thick. It gives much relief, does not irritate the skin and can be changed easily and painlessly. Shaving is unnecessary. The bandage may be reenforced with adhesive tape placed outside of it. Brown[160] applies adhesive plaster over a snugly fitting undershirt (track shirt).

A standard treatment of fractured ribs is strapping with adhesive plaster. The proper application of the adhesive strapping requires considerable skill on the part of the surgeon and a marked degree of cooperation on the part of the patient. If possible, the patient will be best treated standing, but if he is too faint or weak, a sitting position is permissible. Two assistants will raise his arms to the level of the shoulders and will steady him. The patient is instructed to stand with his feet apart in a braced position. The hair having been shaved from the chest and the skin cleansed with benzine and dried, 3 inch strips of adhesive plaster which are long enough to encircle the chest completely save for a space of 6 to 8 inches on the unaffected side are applied.

*Zimmer Manufacturing Company, Warsaw

Application of compound tincture of benzoin to the skin will make the adhesive plaster more adherent. The first strip is started high up on the chest and is fixed at the posterior axillary line on the unaffected side. The patient is then instructed to exhale his breath completely and to hold it in expiration as long as possible, and when breathing becomes necessary to do so as shallowly as possible. The top strip is then forcibly wound around the chest and made tight (Fig. 211). The patient's shoulders should be braced, and if he is standing his feet should be held well apart. Without permitting the patient to take a deep breath the second strip is applied in the same manner overlapping the first strip for a space of 1 to 1½ inches. Subsequent strips are applied in the same manner until the entire side is strapped or at least until the strapping reaches 4 or 5 inches below the site of the fracture. Webb[161] emphatically recommends the complete encirclement of the chest during

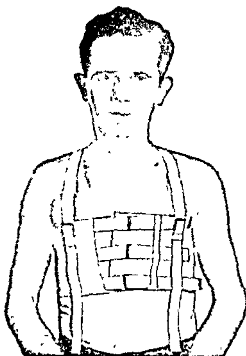


Fig. 210.—Zimmer rib splint. This is an adjustable canvas belt with shoulder straps. (Zimmer Manufacturing Co., Warsaw, Ind. A similar belt is made by the DePuy Mfg. Co, Warsaw, Ind.)

expiration with adhesive tape for the first ten days. Blades[162] advises the encirclement of the lower costal margin with a single 4 inch strip of adhesive plaster regardless of the level of the fracture. The success of the strapping depends upon the tightness and the smoothness with which it is applied. Folds and wrinkles in the adhesive tape, while to some extent unavoidable, if marked will cause considerable discomfort to the patient. In women the breasts should be carefully avoided. The edge of the adhesive tape which passes under the breasts should be protected by a gauze pad. Straps may be passed both under and over the breasts. They should not pass over the epigastrium if possible. The almost instant relief from severe pain is very gratifying. It is desirable to have this adhesive strapping remain in place for at least three weeks. The warmth of the body will often cause the adhesive to slip so that it no longer immobilizes the affected side. In this case, fresh

strapping will have to be applied. Before this is done, however, the skin should be thoroughly cleansed, and any cutaneous infections which have been discovered under the old strapping should be appropriately treated. The complaint by the patient of pain and tenderness underneath the strapping in a small locality should be investigated by cutting out a window. Boils and even carbuncles have been known to form under this adhesive strapping. Elastic knit bandages, 6 inch width, are often useful in rib fractures.

Harmon and his colleagues[163] say: "The use of a local anesthetic with a prolonged action in 32 cases of minor fractures of ribs and 5 major thoracic injuries eliminated the necessity of strapping the chest wall with adhesive tape and the excessive use of sedatives to control pain. A more physiologic state was thus preserved throughout convalescence. It

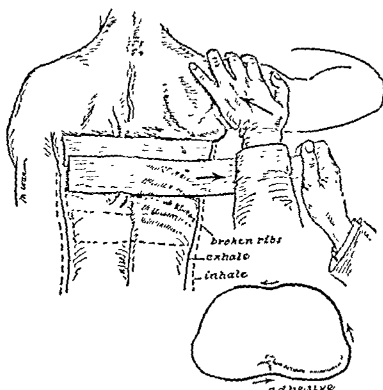


Fig. 211.—Method of strapping the chest for a fracture of the rib. The straps are applied very firmly from the top downward while the patient holds his breath in exhalation. The author feels that the Zimmer rib splint (Fig. 210) or tight encirclement of the chest with strong muslin bandages is usually preferable to strapping in rib fractures.

is our clinical impression that the comfort of the patient is greater with this type of treatment than with any other."

In regard to the local anesthetic, they say: "While the results of treatment with procaine hydrochloride alone were satisfactory, the adoption of a double solution containing 0 5 [illegible] nt eucupine dihydrochloride (isoamylhydro- [illegible] rine hydrochloride (10 drops per hundred [illegible] olonged primary anesthesia (three or four [illegible]

Smith[164] has good results with the injection of about 7 cc. of 1:1000 percaine (nupercaine). Some cases required several injections. Prophylactic administration of sulfonamides may be advisable in rib fractures.

A fairly common complication of fracture of the rib is contusion of the lung. The blood effused into the lung parenchyma will be visible in the *x*-ray

plate and will generally be absorbed or expectorated by the patient. Puncture of the lung by a sharp rib end may bring about hemothorax, which, if not too large, will absorb. Aspiration of the pleura, however, is indicated in some cases if the quantity of blood is large and there is embarrassment of respiration. The author[165] reported a case of ileus following fracture of the eighth and ninth left ribs. Reports of 4 other similar cases were found in the literature. Altemeier and Wadsworth[166] have reported 10 additional cases at the Henry Ford Hospital. *Hinton and Steiner*[167] *have analyzed 29 fatal* cases with rib fractures. Fracture of the first rib by muscular violence has been reported.[168]

When there are multiple rib fractures, usually bilateral, the condition is termed "stove-in chest" and the prognosis is poor. Hagen[169] reports a desperate case of this type in which dramatic improvement followed the placing of the patient in a Drinker respirator.

Strain of the Costochondral Junction.—A very common injury which is *the result of falls or blows upon the chest is strain of the costochondral* junction. This condition is quite painful and has a marked tendency to chronicity. The only treatment of avail is immobilization by strapping with adhesive tape and the application of external heat.

Slipping Rib Cartilage.—Holmes[170] says:

"1. Slipping rib cartilage is a definite lesion involving the anterior ends of the anterior cartilages of the vertebrochondral ribs, namely, the eighth, ninth and tenth on either side. It is not concerned with the costochondral articulations.

"It is due to a loosening of the fibrous hammock-like attachment of the anterior end of the cartilage, and the loosening is followed by deformity—a curling upward of the cartilage end—so that it rises to the inside of the rib above and comes in close relation to the intercostal nerve which is the seat of pain.

"It is always of traumatic origin, either direct or indirect, more often the latter.

"It occurs singly, and as multiple and bilateral lesions.

"Age or sex are of no consideration.

"2. The cartilage deformity develops over a period of time subsequent to the injury. The patient frequently does not associate the injury with the complaint, and the cause is not recognized; this is particularly true of indirect injury.

"Since the rib border is the weakest part of the chest wall, a direct injury, even of minor severity, may cause the lesion, *especially in the nonathletic.*

"Due to the muscle attachments and the different directions and degree of muscle pull, this loosening may occur in many ways.

"There is a wide distribution of nerves involved, namely, the intercostals connected with the sympathetic system, and the brachial and lumbar plexuses. By way of the sympathetics, the intercostal nerves are connected with the cardiac, the solar or epigastric, and the hypogastric plexuses which, in turn, have branches to the viscera.

"Thus the pain manifestations cover a wide field. The intensity of pain complained of is frequently well away from the rib border—in the anterior chest wall, breast region, shoulder blades, back, abdomen, and so forth; but usually there is an associated general soreness of the 'ribs' (so spoken of by the patient), and a localized area of tenderness at the rib border.

"3. Diagnosis is made from the history of pain in the chest or abdomen over a period of time. Usually the pain is in the anterior chest, at or near the rib borders.

"There is a localized area of pain at the rib border, the site of the lesion.

"By digital manipulation, with the patient in the supine position and the knees flexed, the abnormally loosened and deformed cartilage can be brought out over the rib border with a click and a pain that is diagnostic.

"*X*-ray examination is of assistance in ruling out deeper lesions of the chest and abdomen.

"4. The pain of slipping rib cartilage is not like other pains. It is usually a dull ache and is often tolerated for years, even a life time. Some patients scarcely realize that they

are impaired until operation is performed and their annoyance is taken away. Others suffer severely, and are acutely and completely incapacitated.

"There are many cases of obscure pain associated with the chest and abdomen which may have as their background the slipping rib cartilage. Therefore, examination of the rib borders should be made routinely, and information relative to the syndrome should be generally disseminated.

"The acute condition should be treated conservatively. Later, in the course of from one to three months, if the symptoms persist and with sufficient severity, excision of the loosened, deformed cartilage or cartilages involved should be advised. Operation results in permanent and usually immediate relief of symptoms. There has been no mortality."[171]

Minor Fractures of the Sternum.—All linear fractures of the sternum without displacement may be regarded as minor fractures because their treatment is limited to rest. Strapping with adhesive tape may be helpful.[172] Edmunds[173] reports a case of non-union of a fracture of the sternum in which cure was effected by open reduction and internal fixation of the fragments.

Fractures of the Costal Cartilages.—Stimson,[174] who has collected reports of an interesting series of cases from the literature, states that fractures of the costal cartilages "occur much more frequently at or near the junction of the cartilage and rib than at any other point, and more frequently in the seventh and eighth ribs that at any other point." The diagnosis is based upon localized pain and the abnormal contour of the costal cartilage. The prognosis is excellent, and union will generally take place in three or four weeks following immobilization with adhesive plaster or encircling muslin bandage.

Dislocations Involving the Trunk.—*Dislocations of the Clavicle.*—The clavicle may become dislocated from its sternal or scapular attachments. Luxation of the claviculosternal articulation is common and follows a blow upon the shoulder, such as may result from a heavy fall. It is extremely difficult, if in fact at all possible, to maintain reduction of this dislocation by a pressure pad upon the central end of the clavicle. Posterior dislocation of the sternal end of the clavicle has been described by Greenlee.[175] It will be necessary to treat this injury by the use of a clavicular cross splint or brace which will strongly retract the shoulders and permit the clavicle to resume its natural position. As in the dislocations of the outer end, the immobilization will have to be maintained for a prolonged period of time, four weeks being the minimum requirement. Open operation in this case is occasionally necessary. Mitchell[176] has never seen a patient who could play football after a dislocation of the outer end of the clavicle unless an operation had been efficiently performed.

The presence of dislocation of the inner end of the clavicle is generally very easily established by palpation. The clavicle will be elevated from its normal position and in most cases quite readily may be reduced by simple pressure upon the projecting end. The end, however, will immediately [illegible] e is removed.

[illegible] *Dislocation of the Acromial End of* [illegible] acromial end of the clavicle is a fairly common injury, particularly to football players. It may be partial or complete. According to Shaar[177] the "lesion produced by injury is usually the tearing across of the superior acromioclavicular ligament from the clavicle, which remains attached to the acromion. This occurs when the

scapula rotates on an anteroposterior axis with the coracoid process acting as a fulcrum, the acromion process descending while the outer end of the clavicle ascends. In severe cases the coracoclavicular ligament is torn and the displacement is considerable.

"The cause of the dislocation is usually a violent force applied to the shoulder so as to drive the scapula forward and the acromion downward and inward."

The diagnosis is usually made easily. There is tenderness at the acromioclavicular joint. The distal end of the clavicle is elevated; it may be replaced but immediately comes out of place again. Meyerding[178] defines complete separation as one in which not only the acromioclavicular ligament but also the coracoclavicular ligament is torn. Clinically the diagnosis of complete separation may be made when there is separation of 1 inch or more at the acromioclavicular joint.[179] Holmblad advises including both shoulders in the roentgenogram, made with the patient standing.

In practically all cases of partial acromioclavicular separation, conservative treatment will give good results. A satisfactory method is to place a thick felt pad over the outer end of the clavicle and apply a tight Velpeau bandage so that there is upward lift on the elbow, with downward pressure on the felt pad.

Thorndike and Quigley[180] report on the conservative treatment in 138 cases of acromioclavicular separation in college men participating in athletics. They say: "In our experience, elevation of the humerus is unnecessary and adequate fixation can be obtained by simple adhesive strapping across the joint from the lower angle of the scapula posteriorly and carried over the joint and down on to the anterior thorax. A small felt pad is fixed across the joint by [illegible] treatment, and in [illegible] days. . . . In every [illegible] few days treatment was directed as much to the associated contusion as to the dislocation, but the joint was immediately fixed with adhesive tape as soon as the diagnosis was confirmed by the demonstration of increased mobility. The strapping should be removed after forty-eight hours, high frequency diathermy applied for twenty minutes, followed by [illegible] reveals the return to normal. Not until normal function returns do we permit return to contact sport and only then with the protection of supportive adhesive strapping and special pads. The average period of disability for this series of separations was 10.5 days for all these types of injuries."

Shaar has obtained very satisfactory results in 5 out of 6 cases with his elastic traction splint. He says that "in cases in which the conoid and trapezoid ligaments are partially or completely ruptured" his splint is of no value and only open reduction can reasonably assure a satisfactory result. The splint is so constructed as to "sustain the weight of the arm, lift the shoulder upward, and make sufficient pressure on the outer end of the clavicle to counteract the spasm of the trapezius without undue pressue on the bent elbow."

According to Shaar: "The splint (Fig. 212) can easily be made of canvas and rubber tubing It is simple, inexpensive, easily applied and reasonably comfortable. It consists of a piece of [illegible] ment into wh[illegible] the body ab[illegible]

room for the forearm and leaving the hand and wrist free. An axillary pad is placed in position and the elbow and forearm are covered with cotton prior to the application of the splint. Next to be applied is the traction strap. The middle part consists of canvas, and its extremities are made of rubber tubing. This is placed over the outer end of the clavicle, which is protected by a felt pad, and is then secured to the canvas body strap in front and behind the elbow as graphically presented in Fig. 212. The rubber tubing supplies the constant traction which is the most desirable feature of the splint, a traction that can be easily adjusted and regulated by the size of the tube and the tension to which it is subjected. The third and last strap of canvas is to prevent the traction strap from slipping over the shoulder. One end of it is secured to the body strap in the vicinity of the anterior axillary line of the normal side. Then it is carried across the chest to the affected shoulder, passing first under and then over the traction strap, making a sort of loop. Then it passes across the back to be secured to the body strap near the posterior line.

"When the elastic traction splint is properly applied, it does not require further adjustment except for increasing or decreasing the traction by means of the rubber tubing, which is so readily accessible that the rest of the splint need not be disturbed."

Copher[181] has made a valuable contribution to the treatment of *acromioclavicular separation*. He says: "The rational position for fixation of the shoulder after reduction

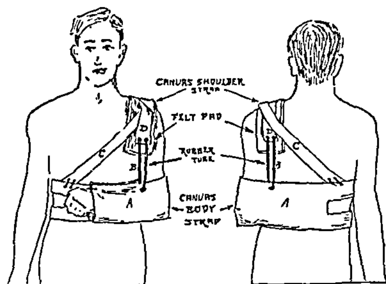


Fig. 212.—Splint for upward dislocation of the acromial end of the clavicle. (Shaar, C. M.: J. A. M. A. 92: 2083, 1929.)

of an upward dislocation of the outer end of the clavicle is backward and upward. A simple and comfortable method of securing this position is accomplished by the use of an elastic bandage placed about the shoulders in a figure of eight. Before the elastic bandage is applied a pad of cotton and saddle felt of 1 or 2 inch thickness and about 2 inches in diameter is placed over the outer end of the dislocated clavicle and held in place by adhesive plaster. The axillary folds and spaces are padded with cotton for comfort and to absorb perspiration. The elastic bandage is applied fairly tensely about the shoulders in the manner of a figure of 8 and so as to make pressure on the pad overlying the outer end of the dislocated clavicle. It is desirable to use a bandage containing rubber. The elastic bandage pulls the scapulae and hence the acromion process backward and upward and at the same time effectively depresses the pad and the dislocated end of the clavicle.

[illegible]

normal level. An axillary pad is used to prevent inward displacement of the shoulder.

"Fixation by this means should be made for four to six weeks. The elastic bandage can be removed occasionally to allow tightening when replaced and to permit cleansing and powdering of the parts. After the use of the elastic bandage is discontinued the arm

should be carried in a sling until complete healing has occurred. This method of fixation has been used satisfactorily on patients and it is believed that it will materially reduce the number of patients on whom it is necessary to perform an open operation for cure of the dislocation of arthrodesis, fixation by suture or by other means."

The harness devised by Warner[182] is useful. Hart[183] uses a plaster spica cast with the arm in 45 degree abduction. Webbing straps attached to the cast apply pressure on a sponge rubber pad on the shoulder.

In cases of complete separation, most surgeons believe that open operation is mandatory. The best method is probably that of Meyerding.[184] Successful results after excision of the distal end of the clavicle have been reported by Gurd[185] and by Mumford.[186] Murray[187] has successfully treated 5 cases by passing one or two Kirschner wires through the acromion process, across the acromioclavicular joint and into the outer third of the clavicle. Mazek[188] reports a case in which this method was used. He says: "This procedure resulted happily, inasmuch as the repair of the rupture of the joint was successful, but unfortunately the wires, instead of remaining where they were so carefully placed, migrated in various directions. Subsequently one was removed from beneath the deltoid, the other from the right lung." Krenn[189] reports 14 complete dislocations treated by conservative means. He believes the support should last six weeks. Of 12 patients followed up, 6 were entirely free from symptoms. Of the 6 others, 3 had signs of arthritis, 2 had habitual subluxation and 1 had difficulty in carrying.

Dislocations of the Vertebrae.—The vertebrae are attached to one another by extremely strong ligamentous structures and when subjected to powerful violence are more likely to fracture than to become dislocated. Dislocation of the vertebrae occasionally does occur and is distinctly a major surgical problem. The mortality in reported cases is some 75 per cent. In many cases of dislocation of the vertebrae there is accompanying injury of the spinal cord.

Dislocations of the cervical vertebrae are not exceedingly uncommon. The bilateral are usually fatal. The unilateral variety is generally benign and is often not recognized. In unilateral dislocation of the cervical vertebrae "an articular process slips over the articular process below it and either catches on top of the lower articular process or slips down in front of it."[190] The condition simulates torticollis. The treatment of this condition is retrolateral flexion and rotation *without extension* (Walton). This is done under general anesthesia.

The dorsal and lumbar vertebrae particularly are capable of rotary motions upon themselves, and upon this circumstance is based the elaborate philosophy of the osteopath, who believes that subluxations may occur between all vertebrae and should be treated by "adjustments." These subluxations are alleged to give rise to a wide variety of systemic symptoms, ranging from infections of the respiratory tract to constipation. It is extremely difficult to conceive that such may be the case, although the explanation offered by the osteopath is that the subluxation causes pinching of or pressure upon the spinal nerves at their point of exit from the spinal foramens. Subluxation is known definitely to occur at the attachment of the fifth lumbar vertebra to the top of the sacrum or involving the fourth lumbar vertebra.[191] This subluxation is accompanied by pain at the site of the injury and by limitation in mobility of the back. It is often remedied by having the patient lie in the

dorsal position and by exerting sudden, forcible upward traction on the small of the back, which brings about accentuated lordosis. The relief may be very prompt and marked. After this manipulation it will be necessary either to immobilize the spine with a lumbosacral belt or have the patient spend a considerable period of time in bed with the back arched in a position of lordosis.

Dislocation of the Ribs.—Costovertebral dislocation of the first and second ribs has been reported by Christopher and Reichman.[192] Brooksher[193] reported a similar injury involving the twelfth rib. A few other cases have been reported. "*Slipping rib*" refers to abnormal mobility of the lower intercostal joints or recurring luxation of a costal cartilage.[194] According to Ballon and Spector,[195] this condition is frequently overlooked and is often confused with angina pectoris, tumor of the lung or gallbladder disease. These authors point out that the pain is lancinating and may radiate; swelling and tenderness are noted over the cartilage; movement of the corresponding arm or the trunk makes a clicking sound; roentgenograms seldom give positive evidence; the condition usually follows an injury, and treatment consists of encircling the entire chest with a binder. Ball[196] describes *displaced ribs* and says the treatment includes manipulation to reduce the rib. Occasionally it is necessary to resect the offending cartilage with or without a small segment of the corresponding rib.[197]

Dislocation of the Gladiolus.—Stahl[198] reports a case of dislocation of the gladiolus behind the manubrium and a novel method of reduction.

Separation of the Symphysis Pubis.—A case of separation of the symphysis pubis without fracture has been reported by Anderson.[199]

(*Dislocations of the shoulder* and various types of painful shoulder are discussed in the section on injuries of the upper extremity.)

Coracoiditis.—This condition has been attributed to a lesion of the articulation, a lesion of the circumflex nerve and subacromial bursitis. From a study of 53 cases Julliard[200] concludes that the underlying factor is a lesion of the coracoid process analogous to the well known lesion occurring in the anterior tibial tubercle, the transverse vertebral processes and the epicondyles. He suggests calling it "coracoiditis." The condition usually follows a fall. It is characterized by pain in the scapular region, pain on pressure over the coracoid process, pain on active or passive abduction of the arm and displacement of the arm posteriorly, and atrophy of the deltoid muscle and arm. Elevation of the arm anteriorly causes no discomfort. The atrophy of the deltoid muscle and arm is secondary and requires some time to appear. There is no anesthesia in the cutaneous area supplied by the circumflex nerve. Injection of novocain into the painful region of the coracoid process enables the patient to perform all movements without difficulty.

The treatment should be prolonged rest. Mechanotherapy is contraindicated. A plaster cast is probably unnecessary. Injections of novocain have given lasting results.

Xiphoiditis.—In this condition there is a painful inflamed joint between the xiphoid and the gladiolus. The condition may be confused with cholecystitis or gastric ulcer. Excision of the cartilage has been done by Engstad.[201]

Hemorrhage from the Umbilicus.—Hemorrhage may occur in newborn babies from inadequate tying of the cord. Such hemorrhage may be serious and requires prompt clamping and religature of the cord. Hemorrhage from

the cord may also occur at some time after the tying of the cord if the granulating wound has become somewhat infected and the ligature slips off or if the infection erodes the umbilical vessels. In this case the control of the hemorrhage may be more difficult because the bleeding point will be difficult to grasp with an artery forceps. Various astringents and clotting agents will be used. Fused silver nitrate, ferric chloride, alum and thromboplastin have been successful in controlling these hemorrhages. Occasionally it will be necessary to pass a deep stitch and so constrict the entire bleeding area.[202]

INFECTIONS OF THE TRUNK

Acute Subpectoral Abscess.—An acute subpectoral abscess is a collection of pus lying between the ribs and the pectoral muscles. This condition is most frequently due to metastatic infection. (See the writer's[203] case reported in the first chapter.) The symptoms are localized pain, tenderness, fever, leukocytosis and limitation of the movements of the arm. The abscess may

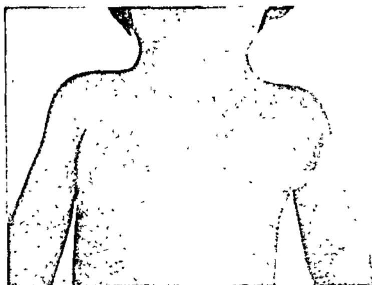


Fig. 213.—Axillary abscess which is partly subpectoral. (Kutzahn, H.: Kleine Chirurgie, Berlin, Urban & Schwarzenberg, 1929.)

be drained through an incision which splits the fibers of the pectoralis major muscle. Milch,[204] however, recommends incision and drainage along the lower border of the pectoralis major muscle (Fig. 213).[205]

Infections of the Umbilicus (Pyoumbilicus, Omphalitis).—The umbilicus is often the seat of pyogenic infections which may be very resistant to treatment owing to the deep ramifications of the skin folds of this area. Hicken and Best,[206] in speaking of pyogenic infections of the umbilicus, say: "In the first place, there are usually coexisting anatomic defects which act as precursors to these infections; secondly, they are usually associated with the formation of umbilical concretions; thirdly, these inflammatory reactions are prone to become chronic, as they have a pernicious tendency to recur; and lastly they eventually terminate in serious complications." Hicken and Best report a case in which an umbilical concretion spontaneously perforated the linea alba, forming an intra-abdominal abscess, and also a case in which drainage persisted for twenty-one years because of retained concretions.

Engel[207] says: "Concretions may be considered one of the more common lesions of the umbilicus. They probably occur only in the deep, narrow type of umbilicus, and this anatomical fault is thus a predisposing factor. A foreign body such as cotton or wool fibers, hair, powder, dust, etc. settles in the deeper portion and sets up an irritation. Nature responds by secreting sebaceous material and forming epithelial cells which are cast off and increase the mass. Later, inflammatory changes may produce a stenosis of the opening, and imprison the concretion which gradually increases in size because it cannot possibly be extruded through the opening. Finally, the extensive irritation leads to severe inflammatory changes, and the patient seeks relief. This lesion does not imply uncleanliness, as it may occur in very meticulous individuals.

"The concretions vary greatly in size from that of a pea to a pigeon's egg. They usually contain hair and cloth fibers, as well as gritty, sandy particles bound together with caseous, sebaceous material containing desquamated epithelial cells. Other foreign bodies such as stone fragments, beads, etc. may settle in the umbilicus and serve as the nucleus of a concretion.

"The two most common presenting symptoms are pain and discharge from the umbilicus. According to the intensity of the inflammatory process, the pain varies from mild pain and tenderness, to severe pain, swelling and fever associated with abscess formation. The periodic discharge of a thin serous or seropurulent secretion should always lead one to suspect this lesion.

"Examination may be relatively insignificant, and the true nature of the condition be overlooked. Concretions may lie very deep, and the opening may be so small as to prevent visualization of the concretion. The swelling may be slight and cases have been reported in which the swelling was some distance from the umbilical depression. Some discharge which is usually malodorous is almost invariably present.

"Several factors may be considered in the differential diagnosis. As in our first case, tumor was suspected, and these cases have been mistaken for cancer. They may simulate any inflammatory lesion such as tuberculosis or syphilis, both of which are exceedingly rare. Because of the presence of caseous material, some early cases are misdiagnosed as tuberculosis. Also, those containing quantities of hair have been erroneously reported as dermoids. Adequate exposure and inspection of the umbilicus, under anesthesia if necessary, is essential, and the presence of a quantity of sebaceous material clinches the diagnosis.

"The treatment consists in dilating the opening and thoroughly removing the concretion. Surgical excision of the sac is not necessary. Recurrence, although possible, is not often observed and probably the associated inflammatory reaction obliterates the cavity. Moreover, the patient who has had the concretion is thereafter very vigilant and careful about umbilical cleanliness, which undoubtedly is a large factor in the rarity of recurrence."

Cleansing the depths of the umbilicus and the institution of hot boric acid fomentations will be successful in many cases. Roentgenographic visualization by means of injected lipiodol or thorotrast may be very helpful in demonstrating the depth of the lesion or the presence of a concretion. Recurrences after extraction of the sebaceous plug and irrigation are likely. Not uncommonly it will be necessary to excise the dilated umbilical tract beneath the stenosed external orifice to effect a cure. The entire subumbilical space may become the site of an abscess. Werthemann[208] has emphasized the fact that infections originating in the navel may be the cause of fatal complications even though the skin shows no changes. Organisms may be transmitted to the liver without arrest in the umbilical vein. Because of these serious dangers, particular care must be taken of the umbilicus. An abscess usually requires a generous incision.

Infections of the Breast.—*Infection of the Nipple.*—The nipple may become infected through minute wounds occasioned by the traumatism caused by nursing. These may bring about diffuse cellulitis or an ulceration and fissure formation. The fissures may show little or no infection but may be extremely painful during nursing. In the case of both infection and fissure formation,

nursing will be discontinued until the condition is remedied. Hot boric acid fomentations will be useful *in the case of diffuse inflammations of the nipple.* A useful agent in the treatment of fissures of the nipple will be periodic painting with compound tincture of benzoin. In either event strict attention to cleanliness and asepsis must be stressed.

Acute Mastitis.—Acute mastitis occurs most frequently in nursing mothers and may or may not go on to abscess formation. It is manifested by pain,

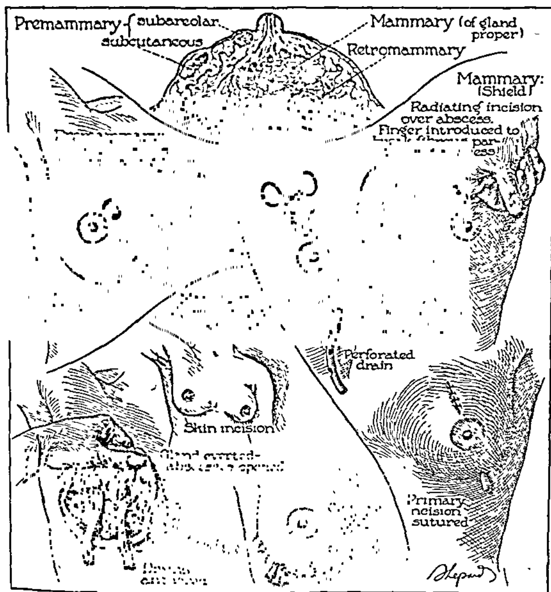


Fig. 214.—Types of incision in mammary abscess. (Courtesy of Johnson & Johnson.)

swelling and redness of the affected parts. It may or may not be somewhat localized. In many cases early acute mastitis may be completely cured by discontinuance of nursing, elevation of the breast and application of hot boric acid fomentations. Chronic mastitis may occur independently of the lactation period and is evidenced by the presence of tender nodules in the breast. Hot applications and elevation of the breast are indicated. Penicillin should be given.

Mammary Abscess.—Abscesses of the mammary gland most commonly occur during the period of lactation. Leo[209] collected reports of 35 cases of purulent mastitis in the male. The patient is conscious of a painful area in the breast which soon becomes indurated, red and extremely tender. At this stage of the inflammation, incision is not indicated, but treatment by elevation and hot fomentations is advised until fluctuation or other definite indications of the presence of pus are apparent. Penicillin alone or together with sulfonamides should be given in all cases. *The common error in the drainage of a* breast abscess is to make the incision too small. The incision should extend well beyond the actual pus cavity. For large abscesses incisions 2 to 4 inches in length will be indicated. Multiple incisions connected by rubber drainage tubes or a rubber dam may be advisable. Such incisions should usually be made radially from the nipple. Bernard[210] favors the circular incisions advocated by Kreis. The abscess cavity will be loosely packed with vaselin

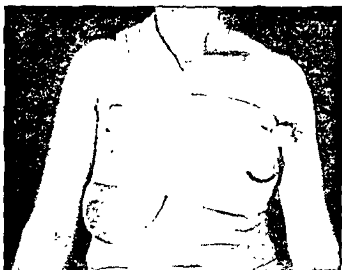


Fig. 215.—Showing the bandage completely applied. By carrying the bandage around the chest wall as much pressure can be applied as desired. Note the Carrel tube brought out through the dressing, the end being kept sterile by placing a small piece of gauze over it. (Hobbs, J. E.: Surg., Gynec. & Obst. 54: 839, 1932.)

gauze, which will not be removed for two or three days, during which hot fomentations are maintained. Decreasing quantities of packing, loosely inserted, will be used until a clean granulating surface presents.

Hobbs[211] has made the following valuable suggestions for the treatment of breast abscesses: "Adequate drainage through a very small incision can be established as follows: Under nitrous oxide anesthesia, a stab wound is made large enough to accommodate a [illegible]

[illegible] inserted. The cavity may be thoroughly washed out with hypochlorite of sodium, a painless procedure. There can be no distention of the cavity with fluid for the large tube acts as a reflux." Hobbs regards the supportive dressing as important and says, "A satisfactory binder can be made of gauze 16 inches wide and 5 yards long, folded so that it is 4 inches wide. This can be rolled, wrapped in a cloth, autoclaved, and kept sterile. With the gauze

roll, the mammary gland can be lifted upward by carrying the bandage up over the opposite shoulder, and firm pressure can be secured by carrying the bandage around the chest wall (Fig. 215). These binders do not slip, and in addition they serve as a protective dressing. When support is no longer needed and the drainage is scant, a small dressing applied with narrow strips of adhesive tape is substituted."

Chronic Cystic Mastitis. (See the section on tumors of the breast.)

Tuberculosis of the mammary gland is slow in onset and has a chronic course. It may be painful or painless. The breast is usually small and nodular. Tuberculous abscesses may form and discharging sinuses result. Tuberculosis of the breast is probably not as rare as formerly thought. Diagnosis may be made by biopsy. Keeley[212] says the treatment at present "consists of removing the local process." Previously it was thought wise to remove the breast and even the axillary nodes. Hudgins[213] and Nicholson and Gillespie[214] believe that simple mastectomy is the surgical procedure of choice. McGehee and Schmeisser[215] recommend preoperative irradiation, cautery knife excision and postoperative irradiation.

Adenitis.—*Axillary Adenitis* (See section on Cervical Adenitis).—The differential diagnosis between *axillary adenitis* and *axillary furunculosis* may be extremely difficult, and these two conditions are very frequently coincident. The chief reason for the enlargement of the axillary lymph nodes is the presence of an overlying furunculosis, and it has seemed wise to treat for furunculosis with hot boric acid fomentations and in clearing them up to relieve secondarily the axillary adenitis which they have caused. When hot boric fomentations, penicillin or unguents have been employed and the furuncles show definite abscess formation, these should carefully be incised with a very sharp knife and a small gauze or rubber tissue drain inserted. The boric acid fomentations will be continued after the incision has been made. Axillary adenitis which arises from a remote infection, such as that of the hand or arm, will be treated by attention directed to the primary source of infection. In some cases the inflammation involving the axillary lymph nodes will progress long after the causal inflammation has subsided. The writer has seen such inflammation progress so as to produce an abscess as large as a hen's egg, long after the subsidence of the primary infection (on the hand). If abscess formation has taken place in the axillary lymph nodes, wide incision of the abscess with the institution of drainage is indicated. A convenient axillary dressing has been devised by Butler.[216] This consists of a dress shield to which six tapes are sewed. *Chronic axillary furunculosis* is often benefited by *x*-ray therapy. Penicillin and the sulfonamides should be used with proper precautions. *x*-Raytherapy is sometimes helpful. The author has been very much impressed by the favorable results in the treatment of chronic axillary furunculosis with *staphylococcus toxoid.* When acute inflammation has subsided and a draining sinus persists, small elliptical excision and approximation of the skin edges may effect a cure. Excision and skin grafting has been employed by Macey.[217] (See section on Furuncles.)

Inguinal adenitis is a common sequel of pyogenic infections of the lower extremity or of infections, particularly venereal, involving the genitalia. (See also sections on granuloma inguinale and lymphogranuloma inguinale.) The best treatment of the incipient adenitis will include measures directed at the primary source of infection. Penicillin and the sulfonamides should be used with proper precautions. Hot boric acid fomentations for infections

of the extremities will *often bring about quick subsidence of inguinal adenitis.* The pain and swelling will rapidly disappear. Likewise measures directed to the treatment of venereal disease will cause alleviation of the symptoms. In many cases of chancroid and gonorrhea the inguinal adenitis will progress to abscess formation, and a *bubo* will result. Patients with abscess formation of the inguinal lymph nodes should be treated by rest and hot fomentations if the condition has progressed so far that suppuration is inevitable. When fluctuation is apparent, incision and drainage will be employed. The incision should be of generous size, and the loose gauze packing should be changed daily. When *incising an abscess in the inguinal region it will be well to keep* in mind the proximity of the femoral vessels, so that the scalpel will not be carried too deeply, with the danger of injuring them. Pasternack[218] reported 2 cases of tularemic inguinal bubo following tick bites.

Infections of the Pleura.—(*a*) *Pleurisy with Non-Purulent Effusion.*—In pulmonary tuberculosis, in mediastinal tumors and in other, rarer affections a non-purulent effusion into the pleural cavity will take place. Burrell[219] regards every case of pleural effusion as of tuberculous origin unless some other definite cause for it can be found. The presence of this fluid is indicated by some embarrassment of respiration, by dulness on percussion and by the *x*-ray findings. Its removal is indicated for the relief of the respiratory difficulty or for purposes of study to aid in making a diagnosis. Tinney and Olsen[220] say that "the presence of fluid in the pleural space is almost always indicative of serious organic disease." They found the etiology of pleural fluid in 274 cases to be as follows:

ETIOLOGY OF PLEURAL FLUID IN 274 CASES:
SEROUS 193 (70 PER CENT); HEMORRHAGIC 81 (30 PER CENT)

Etiology	Total cases	Per cent of 274	Serous fluid		Hemorrhagic fluid	
			Cases	Per cent of 193	Cases	Per Cent of 81
Carcinoma	141	51	82	42	59	73
Congestive failure	42	15	34	18	8	10
Lymphoblastoma	28	10	18	9	10	12
Pneumonia	24	9	23	12	1	1
Tuberculosis	16	6	15	8	1	1
Cirrhosis of the liver	8	3	6	3	2	2
Chronic nephritis with nephrosis	7	3	7	4		
Miscellaneous conditions	8	3	8	4		

Aspiration of the chest will vary somewhat in accordance with whether a large or a small quantity of fluid is desired. A simple diagnostic aspiration may readily be carried out with a 20 cc. Luer syringe and a needle some 2 inches in length and of at least 19 gauge caliber. The skin is first carefully cleansed and painted with antiseptic solution for a wide area about the site of aspiration. The site is determined upon by percussion, which may be done either before or after the skin is prepared. The site of the puncture should

be either in the sixth interspace in the midaxillary line or in the eighth interspace in the scapular line.[221] A small wheal of local anesthetic solution is made in the skin with a fine needle. Local anesthesia is then further produced by introducing the needle vertically beneath the skin wheal and infiltrating the underlying muscle and parietal pleura. The patient is then placed in a sitting position. Bettman prefers that the patient be placed in the recumbent position. The aspirating needle with syringe attached is introduced into the infiltrated area. It is important to hold the needle and syringe firmly in both hands because considerable pressure is required before the skin is punctured and unless precautions are taken to prevent the needle from going in too rapidly after the forceful penetration of the skin, it will enter the pleural cavity too deeply. Bettman advises the insertion of the needle in the "lower part of the interspace to avoid injury of nerve and vessels which run just under the rib." Too deep penetration may cause a wound of the lung and possibly pneumothorax. The entrance into the pleural cavity is appreciated by the surgeon by the sudden removal of resistance to the needle point.

Bettman[222] says to avoid pneumothorax. "This is accomplished by using a two or three way stopcock between needle and syringe; where a stopcock is not available a small piece of rubber hosing and an artery clamp can be used. Never leave the end of the needle open. . . . Cases have been reported of patients dying or going into shock during pleural puncture. This is called *pleural shock*. The cause of pleural shock is not known. Whether or not there is such an entity as pleural shock is questioned by many men. Infiltration of the skin, subcutaneous tissues, muscle and pleura with novocaine solution and protection against air embolus may decrease the incidence of pleural shock." Bettman advises that a chest should never be aspirated without the use of some sort of manometer. The type of manometer used for artificial pneumothorax in tuberculosis is best. However, "every physician or surgeon who owns a glass syringe and a fairly large bore needle has in this set-up alone an adequate manometer if he will only use it. The use of a simple glass syringe (preferably a small [2 cc.] one) as a manometer is as follows: (a) Remove the little metal gadget which comes with most syringes and which is applied to keep the plunger from falling out. (b) Lubricate the plunger so that it slides easily into the barrel. (c) Use a fairly large bore needle—#15 or larger. (d) Start the explorative puncture with the plunger pulled half way out. (e) Advance the needle and attached syringe slowly, the stopcock of course being open if a stopcock is being used, gently tapping the end of the plunger from time to time while doing this. As long as the needle is in the tissues the relative position of the plunger remains the same. As soon as the needle enters the free pleural cavity one of three things happens. I[illegible]
will be suc[illegible]
either air [illegible]
pheric, or the tip of the needle is in thick fluid, the piston will not change its position until tapped and then will be found to slip into the barrel of the syringe with no resistance. The plunger should then be slowly withdrawn filling the barrel with intrapleural fluid, if any is present. During aspiration of fluid the intrapleural pressure must be evaluated from time to time. If the fluid is thin, this can easily be done by noting whether the barrel of the syringe is sucked in or forced out. Another way is to attach a short piece of rubber tubing to the end of the needle and see at what level above or below the site of puncture the fluid ceases running."

It is extremely important not to remove too much fluid from the pleural cavity at one time. Death has been known to result in eight hours following the removal of 3000 cc. without the introduction of air. Thoracic surgeons sometimes remove from 1000 to 1500 cc. and replace part of this volume with air. Bettman[222] says:

"The amount of intrapleural fluid to be removed at any single aspiration depends upon the purpose for which the fluid is being removed and the underlying pathology in the

particular individual. For diagnostic puncture it is scarcely ever necessary to remove more than 25 cc. to 50 cc. and the removal of such a small amount of fluid will not produce sufficient changes to alter the intrathoracic pressures. If the fluid is being removed to overcome dyspnea or cardiac embarrassment then, obviously, enough fluid must be removed to accomplish the desired effect.

"A fairly good rule of thumb is that if a positive intrapleural pressure exists it is safe to continue to remove fluid until a neutral or negative pressure occurs. It must be remembered, however, that frequently the intrapleural fluid has a definite natural therapeutic effect. For example, in a stab wound or gunshot wound of the lung, the presence of the intrapleural fluid may be the means of controlling pulmonary hemorrhage or even pneumothorax. Also the fluid which accumulates during a pneumonia may be nature's method of putting the diseased lung at comparative rest. In such cases, great caution must be used not to allow the re-expansion of the lung. Where re-expansion of the underlying or opposite lung is contraindicated, a large amount of fluid should not be removed.

"Where the accumulation of fluid, however, is excessive and where re-expansion of the lung itself is a desirable factor, then as much fluid may be safely removed as is necessary to bring back the normal intrathoracic pressure, namely, an intrathoracic pressure of from −2 to −6 cm. of water. If the fluid is being removed for the purpose of getting rid of infected or potentially infective material, then naturally as much fluid should be removed as the patient can tolerate. How much this will be, expressed in cubic centimeters, varies with the individual and with the underlying pathology at the time. If the mediastinum has been stabilized by adhesions, inflammation, connective tissue, etc., and if the underlying lung can withstand fairly large negative pressure, then large amounts of fluid may be removed. As a rule, early in empyema the mediastinum will be labile, the underlying lung may still have some areas of active infection and only smaller amounts of fluid should be withdrawn. Later, in empyema, when the pus has had time to become thick, the mediastinum is usually better stabilized, the underlying lung can usually withstand inflation and it may be safe to remove as much fluid as is physically possible.

"In a stab wound or gunshot wound of the lung where for some definite reason the surgeon feels the fluid is potentially infective and where the surgeon therefore wishes to remove the intrapleural fluid but at the same time maintain the collapse of the lung, air may be allowed to replace some or all of the volume of the withdrawn fluid." Bettman has seen 3500 cc. of fluid removed without untoward symptoms, and yet in other cases removal of 450 cc. has caused shock.

When it is desired to remove a large quantity of fluid it is best to use a syringe with a two-way valve. After a syringeful is withdrawn, the valve is turned and when the piston is pushed in, the fluid escapes to a receptacle. Before the piston is withdrawn, the valve is turned again. Another method employs the Potain aspirator. The aspirating needle is attached to a rubber hose, which in turn is connected to a large flask or bottle, in which negative pressure has been produced by the action of a suction pump. By continuous extraction of air from the negative pressure bottle, the chest fluid will be caused to flow into the bottle until the desired amount has been removed; the aspirating needle is then withdrawn. In cases of tuberculous pleurisy in which the accumulation of fluid takes place rapidly, the fluid may be replaced with air and the rate of accumulation decreased.

(*b*) *Pleurisy with Purulent Effusion* (*Empyema; Acute Suppurative Pleuritis*). —Empyema most frequently occurs after pneumonia. The employment of sulfonamides has materially reduced but not completely prevented the occurrence of empyema following pneumonia. In a study of 124 cases of empyema Oschsner and Gage[223] found the cause to be lobar pneumonia in 61.9 per cent, influenza in 18.1 per cent, tuberculosis in 12.8 per cent, lung abscess in 5.5 per cent and a metastatic lesion and stab wound of the thorax each in 0.9 per cent.

Hudson[224] presents 86 cases of acute empyema treated at the Boston Children's and Infants' Hospital and gives the following interesting table:

Causative Micro-organism.	Cases, Number.	Deaths, Number.	Mortality, Per cent.
Pneumococcus	52	6	11.5
Streptococcus	16	3	18.7
Staphylococcus	6	1	16.6
Mixed bacteria	5	1	20.0
Bacillus influenzae	1	0	0
Not stated	6	0	0

The mortality of children under 2 years of age was 33.3 per cent and that of the older children was 6.15 per cent. The average mortality was 12.7 per cent.

Rising fever (after the drop following the fever of the original pneumonic process), dyspnea, the presence of dulness in the chest, pain, cough, limitation of thoracic *movement, absence of breath sounds, the x-ray pictures of the* chest (which should always be taken with the patient in an upright position) and *aspiration* will establish the diagnosis. Since the use of sulfonamides in pneumonia, empyema has developed later in the course of the illness. Clagett[225] says:

"Often there has been little or no elevation of temperature and the patient has had no specific symptoms except that he failed to recover his strength as rapidly as desired. The empyema develops insidiously and produces few symptoms except a gradually progressive dyspnea owing to collapse of the lung by the accumulated pleural exudate. The empyema cavity is likely to be multilocular. Cultures of the aspirated exudate are often negative for organisms. The leukocyte count may not be elevated. The reduced incidence of empyema and the changes in its character, however, are no excuse for failure to recognize the existence of the disease when it does occur. The physical and roentgenographic signs of empyema are not influenced by chemotherapy, and these examinations should never be neglected."

The *treatment of empyema* varies with the age of the patient, the stage and variety of the infection and the quantity of pus in the pleural cavity. No one method is suitable for all conditions and ages. After careful study of his patient, the surgeon will employ the method indicated at the time but will be quick to change it to a more suitable method as the indications change. The fundamental principles of treatment laid down by the Empyema Commission and by Graham are: "(1) Avoidance of an open pneumothorax in the acute stage of the disease, (2) prevention of chronic empyema by the sterilization and obliteration of the empyema cavity, and (3) provision of supportive measures to raise the resistance of the patient."[226] The two general methods of treatment of empyema are the closed method and the open method. In the former, drainage is carried out without permitting the outside air to enter the pleural cavity. In the latter, open communication between the outside air and the pleural cavity is permitted. Van Hazel[227] says:

"The difference in the 2 methods lies in the fact that the closed method attempts to avoid an open pneumothorax with its danger of increased intrapleural pressure. In a well walled off abscess this danger does not exist. We presume the presence of adhesions when the pus is thick, but this presumption allows for an error in judgment. Therefore, it does seem that preference for the closed method of drainage adds a margin of safety. Whenever the pus is thin and sepsis makes adequate drainage desirable, the closed method is imperative."

Maier and Grace[228] emphasize that in *putrid empyema* (anaerobic empyema) thoracentesis is associated with "considerable danger of a serious thoracic wall infection" and that in these cases open thoracotomy is the treatment of choice. Penberthy and Benson[229] treated 407 children with empyema, the mortality being 10.3 per cent. Their plan of treatment, which illustrates the employment of different methods for different indications, is as follows:

"Aspiration is carried out up to the stage when frank pus is obtained. At this time, the trocar-cannula-catheter method of closed drainage is instituted under local anesthesia. Closed drainage is maintained either by clamping the catheter and aspirating every four hours with a syringe, or by connecting the catheter to a tube under water for continuous drainage. Tidal irrigation is practiced when feasible. After four to five days, some leakage of pus may occur around the tube, but when this happens, the empyema cavity is practically empty and there should be no cause for alarm or the immediate change of the catheter. The original catheter is usually left in place twelve to eighteen days, at which time it is cut and allowed to remain as an open drain. In the event that there is clinical evidence of retention, manifested by a rise in temperature or roentgenologic evidence of fluid, the [illegible] anesthesia is [illegible] 10 cc. or less the tube is removed. It is the practice to measure the empyema cavity every other day with boric or saline solution in order accurately to estimate the progress of the healing. In our experience rib resection with open drainage is rarely necessary in children [illegible] due to a gram-negative *bacillus* was successfully treated by aspirations and intrapleural instillations of penicillin alone. The organism was much more sensitive to penicillin than to streptomycin."

Packard,[231] who presents a mortality of only 6.25 per cent in a series of 64 cases of empyema in children, says that "the greatest single factor influencing mortality was the time of operation—no case died that was operated upon after the pneumonia had subsided and the pus had become thick. Apparently greater operative interference than aspiration is inexcusable in the presence of pneumonia, and even then aspiration should be done only *for pressure*."

In some cases in young children, repeated daily aspiration with a Luer syringe may [illegible] Dr. Joseph Brenneman at the [illegible] The method used and results [illegible] in[232] In 33 cases of empyema which they attempted to treat by aspiration alone, the mortality was 9 per cent. The operative mortality previously had been as high as 25 per cent. Their 122 aspirations were done with either a large Luer syringe or a modified Potain aspirator after induction of local anesthesia. There was no shock or alarming symptom with any of the aspirations. McEnery and Brenneman emphasize that they do not advocate aspiration as a sole routine measure in all empyemas of children. They are interested in presenting evidence "that a *large number of empyemas* can be cured by aspiration alone; that it is the method of choice

in infancy; that empyema is not an emergency and that large amounts of pus can be absorbed; that fibrin masses do not seem as serious an obstacle as is commonly assumed; that a complicating pneumothorax is not an alarming symptom and that when it is a part of a rupture through a bronchus it has often seemed rather to help than to hinder a return to normal; that the evidence is very questionable that pneumococcus empyemas alone are favorable to treatment by aspiration, and that there should be no one routine treatment for empyema in children regardless of the one important factor—the age of the child."

Koster, Kasman and Rosenblum[233] used open drainage after rib resection in 118 cases and found the average healing time to be 45 days. However, when they used closed drainage and contralateral pneumothorax in 21 additional cases, the average healing time was reduced to 20.6 days. Lockwood[234] points out that aspiration, which is usually looked upon as a simple procedure, presents the dangers of (1) pleural reflex with sudden death, (2) puncture of a blood vessel or of the lung and (3) the carrying of infection along the path of the needle. The author cautions against emergency operation unless respiratory and cardiac functions are embarrassed by pressure, against too early establishment of drainage by any method and against too early diagnostic aspiration.

According to Bettman[235] there are three great advantages in the *closed method* of treating empyema: "(1) The method is simpler and safer than any other. (2) The convalescence is shorter, more comfortable. (3) The occurrence of chronic empyema is less frequent." This method consists essentially in the introduction of a small rubber catheter between the ribs by means of a trocar. The trocar is withdrawn, leaving the catheter in place. This catheter is made fast to the skin surface by means of adhesive plaster. The technic is described in detail by Bettman[236] as follows:

"A small skin wheal is first made—procaine ½ per cent without adrenalin is our anesthetic of choice. The subcutaneous tissues are next generously infiltrated. Then with a long, large bore needle on a 20-cc. Luer syringe the deep intercostal tissues are anesthetized. The solution is forced out as the needle is gently pushed ahead infiltrating the path of the needle. In this way the pleural cavity is entered with practically no pain. As soon as the needle [illegible]
fa [illegible]
dr [illegible]
changed into definite pus. If the fluid, on the other hand, is thick, greenish, and definitely purulent, the operation is continued as follows: The skin is nicked with a sharp scalpel at the site of the needle puncture. The needle is now withdrawn and a trocar forced through the intercostal space along the anesthetized tract. A catheter, which before the operation has been found to fit snugly in the trocar, is pushed through the trocar into the chest cavity the moment the obturator of the trocar is withdrawn The end of the catheter is clamped with a hemostat. It is wise to boil the catheter first before trying to fit it with the trocar, because the boiling swells the catheter and a catheter which cold will be found to fit, after boiling will sometimes be found too large. A trocar which will take an F. 14 soft-rubber catheter is the kind we have found very satisfactory. The sheath of the trocar is now withdrawn, leaving the catheter in the chest wall. The catheter is clamped near its emergence from the chest wall—the funnel end is cut off and the trocar removed. This funnel end is then rethreaded on the catheter and acts as a cuff which firmly fits about the catheter at its emergence from the chest wall. A safety pin can be pinned through this cuff without going into the catheter itself, thus the air-tight technic is not broken. Two small bits of gauze at each side of the catheter and two adhesive bands complete the dressing" (Fig. 216).

A thoracic binder may be used. Bettman says that the after-treatment is the most important part of the operation: "Continuous care and watchfulness are necessary. Every two hours the chest is aspirated through the catheter,

not more than a few ounces at the utmost being aspirated at any one time. In order to liquefy the pus and dissolve the large thick fibrin flakes so that the catheter will not be blocked, Dakin's solution is used. After each aspiration a certain amount of Dakin's solution is injected into the empyema cavity, usually about one third the amount of pus aspirated. The aspiration and

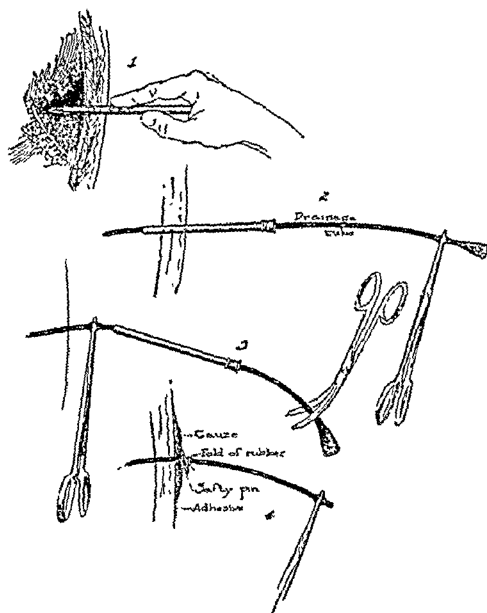


Fig. 216.—*Diagram of the closed method of treatment of empyema.* 1. Method of introducing trocar into empyema cavity. 2. Catheter introduced into trocar. 3. Trocar withdrawn over catheter. 4. Catheter held in place by rubber collar and safety pin to dressings. (Bettman, R. B.: Internat. Clin. 33: 1923.)

injection are done with due regard to the maintenance of air-tight technic. The catheter is maintained in place until after the fluid aspirated has been shown to be bacteria-free on three successive days. Then the catheter is withdrawn and the opening sealed with adhesive." It may be attached to a flask or bottle in which a negative pressure is maintained. As pointed out by

Koch, it is important to see that this negative pressure does not become too strong, and safety devices to prevent its becoming so should be used.

Bettman[237] and Touroff[238] have devised new instruments for introducing the rubber tube in the closed method. Overholt[239] has worked out an apparatus (Fig. 217) for tidal irrigations and suction in empyema. Beardsley[240] has

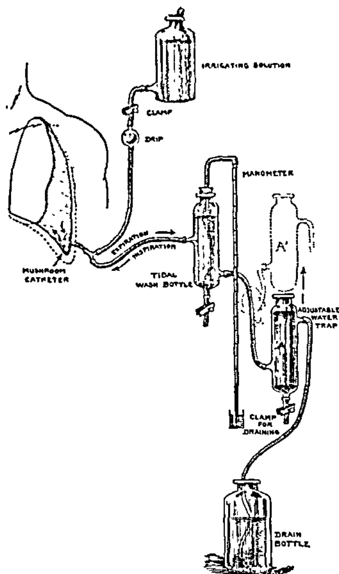


Fig. 217.—Arrangement of bottles in empyema apparatus. Tidal wash bottle is level with chest of patient. Water trap is adjustable and controls amount of suction applied. Manometer is an open one so that it not only indicates variations in negative pressure created in system, but prevents excessive positive pressure in system when patient coughs as air will bubble out through manometer. All of the bottles are made of heavy pyrex glassware. (Overholt, R. H.: Am J. Surg. 15: 548, 1932.)

devised a new empyema tube for continuous suction-irrigation for closed drainage. The tube may also be used for open drainage.

The method advocated by Alexander,[241] of the University of Michigan Medical School, is simple and valuable and is given in detail:

"Before operation the patient is given morphine or codeine but no atropine. Usually the dyspnea is not so great that he cannot lie on his 'good side,' but if it is he may sit across the operating table and lean on an attendant. The posterior axillary line is chosen

as the drainage site for a typically located empyema. That intercostal space is selected which is over the lower midportion of the empyema, as estimated by physical signs, roentgen rays, and confirmatory thoracentesis. The very bottom of the abscess is not sought because here there is undue danger of wounding the diaphragm and because with the air-tight method it is not necessary to obtain absolutely dependent drainage. The assistant surgeon keeps a finger in the selected intercostal space and after all tissues to the parietal pleura have been thoroughly infiltrated with 0.5 per cent apothesine solution, both surgeons push the skin and underlying muscle upward on the ribs and hold them exactly in this position until the incision has been made and the endoscope introduced. It is obvious that, when the drainage tube has been introduced through the tissues held in this way, the tube will pass obliquely through the thoracic wall from skin to pleura as soon as the skin and muscle are released and return to their normal lower position (Fig. 218). This effect may be increased by abducting the patient's arm from the chest before the incision is made. The oblique passage of the tube through the chest wall is responsible for the more or less prolonged maintenance of air-tightness and pus-tightness

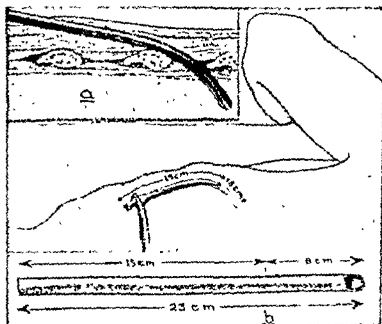


Fig. 218.—After release from upward pressure the skin and muscle drop to a normal position, carrying the tube with them. The tube therefore passes obliquely through the thoracic wall (insert *a*). If it is estimated that 8 cm. of tube should be internal to the skin to have its end well within the empyema cavity, then 15 cm. of tube must be external to the skin if the total length of the tube happens to be 23 cm. (insert *b*). (Alexander, J.: J. A. M. A. 92. 1818, 1929.)

between the tube and the tissues. Under certain conditions this tightness will be maintained only a few days, but usually for one or two weeks; in several of my cases it was maintained for a month or more.

"With the soft tissues pushed upward as described, a narrow-bladed scalpel (Bard-Parker, No. 11) is made to pass from the skin just through the parietal pleura in the middle of the intercostal space; the skin itself is incised only enough to accept snugly the size of endoscope selected for the case. Without letting the skin and muscles change their position in relation to the intercostal space, the surgeon withdraws the scalpel and substitutes a closed hemostat; this is opened and withdrawn, thereby enlarging the incision with less danger of hemorrhage than if only the scalpel were used. Immediately after the hemostat is removed, a bullet-nosed endoscope is introduced with a twisting motion, care being taken that the instrument does not suddenly overcome the resistance offered by the thoracic wall and plunge into the empyema cavity and injure the diaphragm or lung. This resistance is chiefly due to the narrowness of the intercostal space resulting from the spastic contraction of the intercostal muscles in acute empyema. This spasm may be overcome by steady persistent pressure with the instrument, and it is remarkable that in children as young as

three or four an endoscope with an outside diameter of 11 mm. may be entered between the ribs at the posterior axillary line. This size will accept a rubber tube with an over-all diameter of 10 mm. and an inside diameter of 6 mm.

"On withdrawal of the obturator from the endoscope the empyemic pus, which is under pressure, mounts in the instrument and seals the pleural cavity against the entrance of air. The widest rubber tube that the endoscope will accept is fed into the cavity and its end fixed with a hemostat until the endoscope is removed from the chest, when the rubber tube is grasped at the skin, the endoscope slipped off the extrathoracic portion of the tube, and the end of the tube immediately clamped to prevent the escape of pus or the entrance of air. The tube used should be a stiff-walled one so as to counteract the tendency to its collapse from pressure by the adjacent ribs. A catheter is unsuitable in many cases in that its inside diameter is too small to carry off the fibrinopurulent clots.

"It is important to have the inner end of the tube not much more or less than 3 cm. beyond the parietal pleura. If less than 3 cm., the end is in danger of being drawn out of the empyemic cavity during later dressings. Its position can be determined by (1) measuring

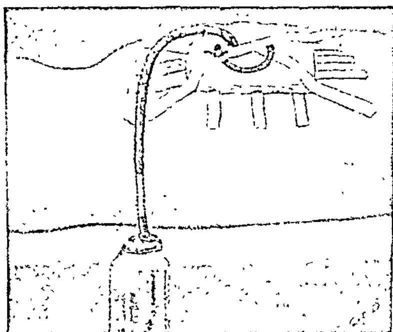


Fig. 219.—Irrigation tube clamped. Drainage tube connected with long tube filled with solution and immersed in jar of solution on floor. Tube tied to jar to prevent accidental displacement of its end from solution and sucking of air into chest. (Alexander, J.: J. A. M. A. 92: 1818, 1929.)

the total length of the tube before introduction, and (2) estimating the oblique distance between the skin and parietal pleura, to which is added the 3 cm. of the tube that should project into the cavity beyond the parietal pleura.

"As a single intercostal tube is more likely than not to become plugged and fail to evacuate the [illegible]
tior [illegible]
ant [illegible]
tub [illegible]
has the disadvantage that even the small amounts introduced must necessarily break recently formed pleural adhesions that are attempting to bring about closure of the cavity. The second tube should be a small one, such as a Dakin tube. It is introduced through a narrow endoscope in the intercostal space above the drainage tube, exactly the same technic as that already described being used. . . . No sutures are used to hold the tubes directly to the skin. The sheet of heavy rubber is pierced with two mattress sutures of silk which are tied around the tubes. The rubber sheet is then firmly anchored to the skin with adhesive straps. The serum-soiled gauze beneath the rubber sheet may be changed every day or two after the adhesive tape has been cut at one or more sides of the rubber sheet, which must not be lifted far from the skin as this would pull out the tubes.

"Sudden evacuation of a large amount of [illegible]
sud [illegible]
past [illegible]
by the air-tight method of [illegible]
rule for patients to leave th [illegible]
to it. Only a little pus is ev [illegible]
pressure between the time the obturator of the endoscope is withdrawn and the drainage tube introduced, and that which is washed out when the tube system is being tested at the end of the operation, this amount being replaced, however, by the injected fluid.

"One hour after operation the end of the drainage tube is placed under sterile boric solution in a small sterile vessel, the clamp on the tube is released, and an estimated 60 cc. (30 cc. in small children) of pus is allowed to escape. Then the clamp is reapplied before the end of the tube is removed from the solution, thereby preventing the entrance of air into the chest. The clamp on the irrigation tube is not disturbed. This procedure is repeated hourly until pus will no longer escape. Then the drainage tube is connected through a sterile glass couple with a long sterile tube, filled with sterile boric solution, whose end is placed well under about 10 cm. of sterile boric solution in a sterile gallon jar placed on the floor, after which the clamp on the drainage tube is permanently removed. The long tube should be sufficiently long to permit turning the patient in bed without pulling its end out of the boric solution. As an extra safeguard to keep the tube end under the solution, the tube should be tied with a tape to the neck of the bottle (Fig. 219).

"Now the apparatus is ready for irrigations with boric acid solution or surgical solution of chlorinated soda every two hours. With air-tight tubes the patient need not assume any special posture in order that the solution may reach all portions of the cavity wall. A 30 cc. syringeful of the irrigating solution is connected with the irrigation tube before the clamp is removed After its removal the solution is slowly injected, but never under pressure, as the drainage tube may be plugged. Irrigation is continued until the outflowing fluid is fairly clear of pus. Each time the syringe is removed for refilling, the irrigation tube must be clamped with the fingers or clamp to prevent entrance of air into the chest. For the same reason the long drainage tube to the bottle under the bed must be clamped before it is removed from the bottle at the time this is to be cleaned.

"A week or ten days after operation, pleural adhesions are sufficiently firm and the track of the tube through the thoracic wall is sufficiently fixed to permit removal of the tubes if it is necessary to change them to remove a plug from within them or to have the patient attempt to cough out of the cavity fibrinopurulent clots that will not pass through the drainage tube. At this time closed drainage may safely be abandoned if it is no longer satisfactory because the drainage tube is repeatedly becoming plugged (in which case dependent rib resection then may be necessary) or because of leakage of air and fluid around the tube. In adults secondary drainage by rib resection is occasionally necessary, but in children the closed method alone usually is sufficient. Pressure necrosis of a rib requiring sequestrectomy is surprisingly rare."

Hart[242] has developed a method of treating empyema by "tidal irrigation" and suction, that is, a method which utilizes the respiratory movements to make a back and forth tidal irrigation.[243] The majority of authorities advise the use of Dakin's solution for irrigation, but others believe this solution to be actually harmful in the pleural cavity. In Ochsner and Gage's cases[244] the lowest mortality (10.3 per cent) was obtained by the aspiration of the pleural contents combined with air injections. Intramuscular and local administration of penicillin has been found to be a useful adjunct in the treatment of acute postpneumonic empyema.[245]

According to Graham,[246] closed drainage by aspiration alone is not to be relied upon (1) since there is difficulty in providing adequate drainage, because of the presence in the exudate of large masses of fibrin and necrotic tissue which are too large to pass through the needle or the trocar; (2) because of possible harm resulting from the puncture of a lung or blood vessel, and (3) because of the danger of transforming an acute into a chronic condition

by continued aspiration over too long a period. Drainage by the *open method* has many advocates. Rienhoff and Davison[247] found the mortality for infants at the Johns Hopkins Hospital to be nearly twice as high with closed thoracotomy as with rib resection. Allen[248] says: "If one were forced to choose one method for the treatment of empyema and use it alone, probably the safest and most efficacious would be the resection of a portion of a rib with open drainage. With this method, however, must be exercised judgment as to the proper time to operate. Open drainage too early in the illness, especially with the streptococcus empyema, may result in early death, as occurred in the army camps during the influenza epidemics." The open method consists of the introduction of a large rubber drainage tube into the pleural cavity without effort to prevent the introduction of air. It is particularly suitable in cases in which the empyema cavity is well walled-off by strong adhesions. The rubber tube is introduced either between the ribs or in a space made by the resection of a rib. Intercostal incision is probably not justified in cases in which open drainage is to be employed except in children.[249] A sedative drug should be given before the operation. Local anesthesia will be the choice except for very nervous patients, for whom ethylene or nitrous oxide and oxygen will be desirable. Children may be allowed to sit up if they are to be operated upon under local anesthesia. Lilienthal[250] says that the incision should be parallel to the rib in the posterior axillary line, or 1 or 2 inches behind it, and that it is better to have it a little too high than too low. "The danger of performing a transdiaphragmatic laparotomy is greater than might be imagined." (Lilienthal) The dissection should be carried out carefully and kept close to the border of the rib below the interspace. The pleura is punctured with a scalpel and slowly spread with a hemostat until it will admit a No. 14 or No. 16 French multifenestrated, soft rubber tube. The latter may be connected to a collection bottle. When rib resection is desired, the periosteum of the rib must be carefully anesthetized (in cases in which a local anesthetic is used at both its upper and its lower aspect). A longitudinal incision of the periosteum is then made, and it is separated from the rib for a distance a little beyond the intended rib resection. The rib is then cut with a curved rib cutter and the pleura incised as in the operation in which the rib is not cut. If the open method is employed it will be profitable daily to instill a small quantity, 10 to 20 cc., of Dakin's solution and cause it to be expelled by having the patient cough or deeply inspire. For open drainage of empyema, the tube devised by Leahy[251] (Fig. 220) seems to offer many advantages. Connors[252] packs the empyema cavity with gauze after resecting one or two ribs.

Harloe[253] advocates the closed method and reports a mortality in children of 9.87 per cent in 233 cases. Tanner[254] inclines to the open operation but emphasizes the importance of the slow release of the pus. His mortality in all ages in 189 cases was 10.6 per cent. Bohrer[255] points out how the picture of acute empyema in children varies from year to year. In Steinke's[256] 310 cases, rib resection alone gave the lowest mortality (11.9 per cent). In a most important article Carlson and Bowers[257] say that "the mortality rate of empyema depends chiefly on the nature of the primary disease, the virulence of the etiologic organisms, the complications, and the age of the patient. The mortality rate is but little influenced by the method of treatment, although neglect of drainage or too early open thoracotomy may contribute to the

mortality. . . .Aspiration is the method of choice in the early treatment of empyema before the pus has become thick and during the synpneumonic stage . . . preliminary studies suggest that rib resection and controlled negative pressure drainage constitute a superior technic of treatment." Cohen[258] says, "From a study of 123 cases of acute suppurative pleurisy in children and of comparative data, it is felt that the open method of drainage preceded by repeated aspiration is the choice method of treatment." Willis[259] says: "Rib resection in children should be abandoned except in rare cases and then only after aspiration and thoracotomy [trocar] have been thoroughly tried."

During the convalescence the patient should be instructed to use Wolff blow bottles (Fig. 221) daily.* Children will do well inflating rubber balloons.

Fig. 220.—*A*, cross section showing tube in position with relationship of the inner end to the parietal pleura. *B*, appearance of the outer end with pin in place and wound closed, *C*, cross section showing tube in position following reexpansion of the lung. (From Leahy. L. J.: J. A. M. A. 114: 868, 1940)

The purpose of these exercises is to accelerate the expansion of the lung and, in consequence, decrease the size of the abscess cavity. It is important to see that measures to improve the general health are carefully carried out.

Clagett[225] says that Ehlers[260] listed "the most common causes of persistent empyema as (1) too early removal of the drainage tube, (2) persistence of infection because fibrin was not removed at the time of drainage, or because the tube used did not have a lumen sufficiently large to allow adequate drainage, (3) nondependent drainage, (4) the use of [illegible] in the [illegible] lung [illegible] ation [illegible] dered [illegible] least to some extent due to closed methods of drainage."

* Koster, Kasman and Rosenblum[233] believe that the Wolff bottles are not efficacious and that they are falling into disrepute

Osteomyelitis. (See the section on osteomyelitis in infections of the upper extremity.)—Osteomyelitis of the scapula is very uncommon. It has been thoroughly studied by Wilensky,[261] who advises limiting surgical treatment in the early cases to incision and drainage of frank abscesses and not interfering with the bone structure. Tuberculosis of the clavicle has been reported by Sirkin and Baumgartner.[262] Curettage or excision effects a cure. *Osteomyelitis of the rib* may be primary or secondary to rib resection in empyema. In the former cases it may resemble a tumor.[263] Young[264] finds that acute *osteomyelitis of the ilium* comprises about 5 per cent of all cases of osteomyelitis. He says: "In acute osteomyelitis of the ilium there is, early in the disease, free motion in the hip; whereas, in acute pyogenic infection of the hip joint, motion is practically absent due to muscle spasm. Usually the reference of pain is also different in the two conditions. Flexion and abduction

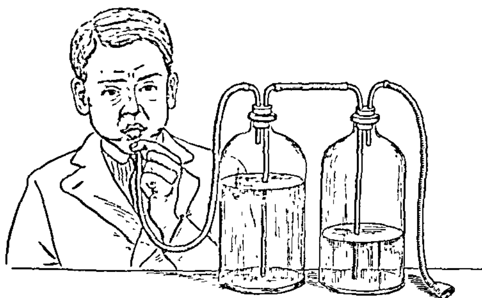


Fig. 221.—Blow bottles used in the treatment of empyema. The patient blows the water from one bottle to another, thus facilitating lung expansion and obliteration of the empyema cavity. (McCombs.)

contracture of the hip occur early in pyogenic infection of the hip joint; much later in acute osteomyelitis of the ilium." Smith[265] says: "*Osteomyelitis of the vertebral bodies* occurs quite frequently in a comparatively mild form which may easily be mistaken for tuberculosis. These lesions have a marked tendency to cause spontaneous bony fusion of the vertebral bodies. They should be treated conservatively until it is certain that a cure will not result in this way."

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CHAPTER XIV

TUMORS AND DEFORMITIES OF THE TRUNK

TUMORS

Benign Tumors

The trunk is commonly the site of a wide variety of benign tumors which are found elsewhere in the body. *Papillomas, fibromas* (Fig. 222), *sebaceous cysts, dermoids, lipomas* (Fig. 224) *and keloids require no different treatment* because of their situation on the trunk.

Bissel,[1] in reporting a case of *lipoma* of the back, weighing nearly 20 pounds, which was successfully removed, says that "there is general agreement that *there is no malignant form (of lipomas), but that they are true tumors, as*



Fig. 222.—Fibroma of the back. (Children's Memorial Hospital, Chicago. Courtesy of Dr. A. H. Montgomery.)

their fat is not reduced in the case of extreme emaciation." Rarely lipomas may originate in muscles or in the intramuscular septums. According to Behrend,[2] some 192 cases of this condition have been reported. The condition has been mistaken for sarcoma. Roentgenograms should be helpful in the differential diagnosis. Caylor[3] calls attention to the lipomas which may simulate hernia, which may be associated with hernia and which may simulate thyroglossal duct cyst. Regan and his associates[3a] have given a careful

description and case reports of benign lipomas which infiltrated muscles.

Adair, Pack and Farrior[4] made a study of 352 lipomas in 134 patients. The regional distribution in their series is shown in figure 223. These authors "have found it convenient to adopt the following clinicopathological classification of lipomas:

"(*a*) The simple, solitary lipoma. This tumor usually occurs at a time in life when the patient is taking on weight. It is soft, lobulated, and located just beneath the integument, to which it is attached, producing the characteristic skin 'tug.'

"(*b*) The multiple lipomas. These tumors, which we believe to be neurolipomas, are not congenital but develop during adolescence or later life.

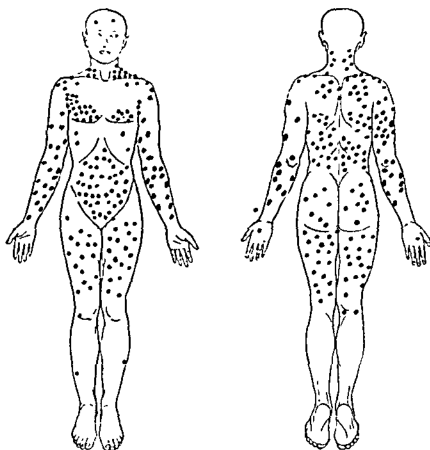


Fig. 223.—Regional distribution of 352 lipomas in 134 patients. (Adair, F. E.; Pack, G. T., and Farrior, J. H.: Am. J. Cancer 16: 1104, 1932.)

They are of firmer texture than the solitary lipoma and are usually not adherent to skin. Because of their symmetrical distribution, they are commonly confused with multiple neurofibromas.

"(*c*) Congenital diffuse lipomatosis. This variety of lipoma is confined to one or two limbs and is usually associated with corresponding enlargement of the muscles and bones of the same limb.

"(*d*) Degenerated lipomas. These tumors really do not need separate classification. They represent the large or bulky lipomas which have undergone certain degenerative changes due to rapid growth or impaired blood supply. The xantholipomas and myxolipomas are well-known examples.

"(*e*) Liposarcomas. As some of the rapidly growing lipomas have shown

malignant qualities, any very cellular lipoma with numerous cells containing only traces of fat should be regarded as malignant and treated as such, especially by complete extirpation. Such tumors, however, are rare."[5]

The writer has seen a fibroma of the neck which extended so deeply into the tissues as to involve the brachial plexus.

Episacroiliac lipoma is the term applied by Ries[6] to small rounded fatty tumors with fibrous capsules which are found in the sacral region. They are relatively mobile, may be symmetric and vary in size from 1 to 6 cm. Ries found these fatty nodules in 317 of 1000 patients examined at random. In 131 cases the tumor was painful, and often it was at the site of backache. Ries removed these nodules in 20 cases and found the relief from backache to be striking in many cases.

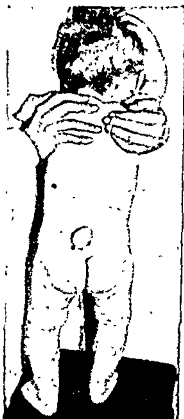


Fig. 224.—Lipoma of the back. (Children's Memorial Hospital, Chicago. Courtesy of Dr. Joseph Brenneman.)

Chondromas of the ribs are not generally of great significance although Lee[7] found it necessary to remove one from the costal sternal junction of the third and fourth ribs. In an interesting study of tumors of the chest wall, Zinninger[8] found that the majority of them were sarcomas of one kind or another. Lyle[9] reported an unusual *hemangioma* of the chest wall.

Desmoids are very hard, tough fibromas, originating in the musculo-aponeurotic structures of the abdominal muscles. They may also be found in other parts of the body. These tumors are composed of fibrous connective tissue and are benign. Pearman and Mayo[10] studied 77 cases of desmoid tumors at the Mayo Clinic. "In 55 cases the tumor occurred in the striate muscle of the anterior abdominal wall, and in the other 22 cases it occurred

in striate muscle elsewhere in the body." The tumors tend to infiltrate the muscle. "These tumors do not undergo metastasis, nor do they endanger life; however, they do tend to recur locally, unless completely removed. Diagnosis is made by finding a fibrous tumor in the muscle; the tumor is fixed by contraction of that muscle. A biopsy is indispensable for diagnosis. Treatment consists of complete excision." (Pearman and Mayo[11]) Judd and Masson[12] removed a desmoid tumor weighing 2550 Gm. and measuring 18 cm. in diameter.

Donald and Caylor[13] report a case of desmoid of the anterior abdominal wall in which fibrosarcoma developed. The smaller tumors may be readily removed under local anesthesia.[14]

The Breast

Tumors of the Nipple and Areola.—Sebaceous cysts originating in the glands of Montgomery are the most frequent tumors in this region.[15] Papillomas, neuromas and angiomas are occasionally found. These small benign tumors are readily removed under local anesthesia.

Macromastia or Hypertrophy of the Breast.—The lesser degrees of this ailment are treated by a supporting binder, but occasionally the breast may reach such a tremendous size as to require amputation for the convenience of



Fig. 225.—Unilateral idiopathic hypertrophy of the male breast.

the patient. The various plastic operations which have been devised to modify the size and shape of the breast are in the province of major surgery.

Unilateral Idiopathic Hypertrophy of the Male Breast (Gynecomastia).—I have reported a case of this interesting condition (Fig. 225). The enlarged breast was a source of embarrassment to the patient and was removed sub-[illegible] report finding 5 cases of gynecomastia [illegible] ve that the best treatment is surgical. [illegible] propionate with a favorable outcome in

2 out of 3 cases of gynecomastia. Buirge et al.[18] had some encouragement with testosterone but finally resorted to surgery, which they feel is preferable.

Supernumerary Breast.—De Cholnoky[19] says that "accessory breasts are commonly observed (1 to 2 per cent) in both sexes and are usually situated in the milk line. . . . No operation is indicated for these anomalies unless there are 'psychologic' symptoms or unless their location or tumor formation warrants removal."

Breast Tumors.—Bevan[20] gives the following classification of breast tumors which he believes to be the best for clinical purposes:

Classification for Tumors of the Breast (Bevan)

Benign[21]

1. Fibro-adenomas, which consist of:
   Pericanalicular and intracanalicular, with the special cauliflower type called cystosarcoma phyllodes; intraductal fibro-adenoma.
2. Papillomatous cysts; true tumors of the breast resembling true ovarian tumors.
   These papillomatous cysts, which are classed as true neoplasms and not as cysts, developing in the course of fibrocystic disease of the breast.
3. Fibrocystic disease of the breast or chronic cystic mastitis.
   Single blue-dome cyst; multiple cystic disease; chronic fibromatosis of breast.

Malignant

1. Sarcoma, probably forming less than 2 per cent of malignant tumors.
   Spindle cell and round cell, very few giant cell; many sarcomas are more or less cystic.
2. Carcinoma, forming more than 98 per cent of malignant tumors
   (*a*) Simple carcinoma.
   (*b*) Diffuse carcinoma.
   (*c*) Medullary carcinoma.
   (*d*) Colloid carcinoma.
   (*e*) Adenocarcinoma.
   (*f*) Carcinomatous cysts.
   (*g*) Paget's disease.

Benign Breast Tumors.—Benign tumors of the breast are more common than malignant tumors up to the age of 40; from 40 to 59 years the incidence is about the same; after 50 the incidence of benign tumors decreases.[22] The female breast is best examined with the patient lying supine, and it is preferable for the examiner not to be told the location of the tumor. The flat of the hand or the four fingers methodically press all sections of the breast against the underlying pectoral muscles. Some surgeons prefer to examine the breast with the patient sitting. Should a lump be palpated, the examiner will note if it is tender or painless, if it is fixed to the skin or to the pectoral fascia and if it is round or irregular in contour. The axilla should always be examined for the presence of palpable nodes. However, I do not believe that it is possible to exclude a malignant growth by palpation. All lumps of the breast should be removed for microscopic examination. (See the discussion of biopsy.) Mammography, or the injection of a contrast medium into the milk ducts to aid in the diagnosis of a tumor, is an interesting method, but it lacks the safety and certainty of biopsy. The roentgen diagnosis of tumors of the breast has been extensively studied.

The existence of *fibroadenomas* in the female breast is extremely common. They also occur uncommonly in the male breast. The diagnosis is made by palpation of a hard, definitely circumscribed, single or multiple, rounded

tumor in the breast tissue. This nodule will be found adherent neither to the skin nor to the underlying pectoralis major. It is generally freely movable. De Cholnoky[23] studied a large series of breast tumors and found 61 per cent to be benign. In Erdmann's[24] series, only 44 per cent were benign. In MacCarty's[25] series of 13,168 cases of breast lesions, 56 per cent were benign.

Ewing[26] describes the *papillary intracystic fibroadenoma* or *cystadenoma.* Typically it is enclosed in a cyst wall. "The tumor may appear as a papillary growth attached to one segment of the wall and incompletely filling the cyst, or it may occupy the entire cavity distending the wall, or numerous points of fusion unite the tumor with the wall. These tumors develop by papillary growths into the larger ducts." (Ewing) They may be accompanied by a bloody or serous discharge from the nipple. Hart[27] studied 124 cases of intracystic papillomatous tumors of the breast. There were 104 benign and 24 malignant tumors. He says that in the benign papillomatous cyst there is a nipple discharge, usually bloody, in 66 per cent of the cases. "This tumor sometimes gives a nipple discharge without a palpable nodule. This discharge alone demands close observation, but it is not an indication for operation." Ninety-eight per cent of the tumors are in the female breast, generally in the central zone. The duration may be as high as thirty years. "They may have a firm, nodular, and indurated consistency, due to multiple cysts, densely filled with fluid and so situated as to suggest a single tumor." They occurred as a single tumor in 83 per cent of Hart's cases. While usually small, they were over 6 cm. in diameter in 38 per cent of the cases. There may be retraction of the nipple. A change in size of the tumor associated with a bloody nipple discharge is almost pathognomonic of a papillomatous cyst. Pathologically, there is usually a cyst with one or more papillomas, a thin wall and no invasion. The interesting condition known as *fibrosis mammae diffusa*, which is hyperplasia of the connective tissue, has been studied by von Gusnar.[28]

Chronic Cystic Mastitis.—From a review of the literature on *cysts of the breast* (*cystic mastitis, chronic cystic mastitis*) and his experience with 375 cases of this condition, Bunts[29] draws the following conclusions:

"1. It is probable that all cystic conditions of the breast are due to the same primary cause; therefore a classification of benign cystic conditions is of neither etiologic nor clinical importance.

"2. It is possible that the same etiologic factors that produce cystic conditions of the breast also produce carcinoma, but there is no final evidence at the present time that cysts of the breast *per se* are proemial in character.

"3. It appears evident that, at least in certain cases, cystic conditions of the breast, in common with other types of benign tumors, may be due to intestinal toxemia.

"4. The indicated treatment of cystic conditions of the breast may be summarized as follows:

"(*a*) In cases of diffuse chronic cystic mastitis in women under thirty years of age a waiting policy may be adopted. After the age of thirty years the breast should be examined at intervals of not more than six months to determine whether there are signs of a recurrence of the cysts or the initiation of a malignant growth.

"(*b*) Single cysts should be removed and subjected to histologic study. If the growth proves to be benign nothing further need be attempted, but

the patient should be examined at frequent intervals to determine whether there is a cyst elsewhere in the same breast or in the other breast.

"5. In the presence of a cystic condition of the breast, the possibility of carcinoma should be borne in mind." In the painful diffuse types of chronic cystic mastitis, ovarian residue, 5 grains three times daily, is often very effective in relieving the symptoms.

In discussing the relationship between chronic cystic mastitis and malignant tumors, Procter and his colleagues[30] say: "The problem of interpreting the pathology and the management of so called chronic cystic mastitis is yet unsolved. The multitude of names applied are confusing and an effort has been made to clarify this. Many authors using the common name feel that it is unsatisfactory, including as it does borderline condition between the physiological and pathological, as well as benign tumor masses and malignant hyperplasia." There is a feeling on the part of many pathologists that chronic cystic mastitis often becomes carcinomatous, and when this condition is found the indicated treatment is simple mammectomy. Taylor,[31] after thoughtful study, is of the opinion that "glandular therapy up to the present time has been of no benefit in the treatment of chronic mastitis." Auchincloss and Haagensen[32] warn against the administration of estrogenic substances and believe that progynon B was a probable contributing cause of carcinoma of the breast in one of their cases.

In a study of *chronic cystic mastitis* Rodman[33] says: "Conservatism is justifiable in dealing with abnormal involution, provided one fully appreciates the somewhat rare development of carcinoma in such cases. Any tumor which does not change with local treatment (support and mild counterirritation) after one menstrual period has been passed should be removed by local excision and submitted to frozen section, the pathologist choosing the part to examine microscopically. If there is reasonable doubt in the mind of the pathologist who has made this subject one of special interest, after microscopic examination of the frozen section, the surgeon should proceed with the radical operation as for carcinoma."[34]

Plasma Cell Mastitis.—Of this condition Adair,[35] who analyzed 10 cases, says: "This lesion is difficult to distinguish from mammary cancer by clinical signs alone. The signs [illegible]

The typical history is that at some preceding date an inflammatory process was present in a nonlactating breast, which process was accompanied by redness, mild tenderness and [illegible]

The present analysis of our cases shows, however, that this is a diagnosable lesion clinically. The microscopic interpretation is very puzzling, as at times the lesion closely simulates comedocarcinoma and at other times tuberculous mastitis. It is a precancerous lesion and should be treated by local removal only."[36]

Milk retention cysts (*galactoceles*) are uncommon and when found are seen almost exclusively in the lactating female. "The contents of the cyst are at first pure milk. Later, owing to the absorption of the fluid contents, or to clinical changes, it may become thick and creamy, cheesy, or oily in character."[15] The swelling is smooth and rounded and compression of it may uncommonly cause milky fluid to exude from the nipple. The treatment is the excision under local anesthesia.

Moulonquet-Doléris[37] calls attention to the fact that "in its early stages cancer of the breast may simulate a number of conditions, notable among

which are: 1. Necrosis of cysts of the premammary fat. 2. Chronic infectious mastitis. 3. Syphilis and tuberculosis. 4. Isolated cysts. 5. Mammary engorgement occurring in nervous and tuberculous women. 6. Generalized dystrophy (Reclus' disease)."

Adair[38] gives the following list of those benign lesions which at times simulate carcinoma and occasionally give one or more of the signs of cancer, such as, skin attachment, nipple retraction, breast elevation, peau d'orange or irregularity of the breast contour: (1) traumatic fat necrosis, (2) plasma cell mastitis, (3) chronic lactation mastitis, (4) subacute inflammatory mass, (5) tuberculous mastitis, (6) gumma and luetic mastitis, (7) deep abscess (occasionally), (8) cyst (infrequently)—more commonly when within the areola, (9) intracanalicular fibroadenoma (rarely), (10) traumatic mastitis and (11) benign lesions, such as fibroadenoma or papillary cystadenoma lying *within* the areola.[39]

Sanguineous Discharge from the Nipple.—Adair[40] made a study of 108 cases in which there was a bloody discharge from the nipple and found cancer to be present in 47.2 per cent and a benign condition in 52.8 per cent.[41]

Lee says,[42] "A discharge of *blood from the nipple*, in a woman fifty years of age or over, is a highly significant sign, and I believe that in 60 or 70 per cent of the cases in this age group, cancer will be revealed after mastectomy." Wainwright[43] believes that bleeding is not sufficient alone to warrant the presumption that the lesion responsible for it is either malignant or benign. Statistically, the chances of a malignant or benign lesion are about even. The most common benign lesion causing bleeding is duct papilloma. This author believes that in cases of bleeding of the breast which has occurred continuously or intermittently for a month, safety demands removal of the bleeding tissue. If a palpable tumor is found, local excision may suffice. If several tumors or a diffuse thickening can be felt or if no tumors can be demonstrated, the entire breast should be removed. Babcock[44] has described a simple and ingenious operation for the excision of an isolated milk duct in cases of discharging nipple. All patients, however treated, should be kept under careful observation.

Paget's Disease of the Nipple.—In this condition, which occurs chiefly in women over 40, the skin of the nipple and the area around it becomes reddened, and desquamation occurs. "Infiltration soon produces a bright red, granular, indurated surface, with a sticky yellowish discharge which, by forming crusts, may obscure the nature of the lesions save at the border, which continues to be characteristic—sharply defined, indurated, and sometimes distinctly raised."[45] It is known that cancer of the breast will follow Paget's disease of the nipple, and by some[46] it is believed that Paget's cells are cancerous from the beginning. Paget's disease has been found in regions remote from the nipple.[47] Muir[48] believes that "Paget's disease is the result of the invasion of the epidermis of the nipple by tumor cells of glandular type which reach it from the upper extremities of the lactiferous ducts affected by neoplastic disease. These tumor cells constitute the 'Paget cells.' Their growth is intra-epidermal." Once the diagnosis of Paget's disease of the nipple is made, prompt and total removal of the breast is indicated.

In their article Eller and Anderson[49] state: "Our observations in these cases substantiate the reports of Cheatle, Pautrier, Fraser, and others who gave cogent reasons for removing Paget's disease of the nipple from the

the patient should be examined at frequent intervals to determine whether there is a cyst elsewhere in the same breast or in the other breast.

"5. In the presence of a cystic condition of the breast, the possibility of carcinoma should be borne in mind." In the painful diffuse types of chronic cystic mastitis, ovarian residue, 5 grains three times daily, is often very effective in relieving the symptoms.

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Plasma Cell Mastitis.—Of this condition Adair,[35] who analyzed 10 cases, says: "This lesion is difficult to distinguish from mammary cancer by clinical signs alone. The signs of cancer are present, such as hardness of the tumor, retraction of the nipple, skin attachment, peau d'orange appearance and axillary nodes. With such signs present, the only possibility of arriving at a correct diagnosis lies in evaluation of the characteristic history. The typical history is that at some preceding date an inflammatory process was present in a nonlactating breast, which process was accompanied by redness, mild tenderness and mild discomfort. As the symptoms of the acute phase pass off, a residual hard mass remains. This mass is not tender or painful. In 8 of our 10 cases, mastectomy was performed because of the difficulty of diagnosis. The lesions had most of the signs of mammary carcinoma. The present analysis of our cases shows, however, that this is a diagnosable lesion clinically. The microscopic interpretation is very puzzling, as at times the lesion closely simulates comedocarcinoma and at other times tuberculous mastitis. It is a precancerous lesion and should be treated by local removal only."[36]

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Moulonquet-Doléris[37] calls attention to the fact that "in its early stages cancer of the breast may simulate a number of conditions, notable among

which are: 1. Necrosis of cysts of the premammary fat. 2. Chronic infectious mastitis. 3. Syphilis and tuberculosis. 4. Isolated cysts. 5. Mammary engorgement occurring in nervous and tuberculous women. 6. Generalized dystrophy (Reclus' disease)."

Adair[38] gives the following list of those benign lesions which at times simulate carcinoma and occasionally give one or more of the signs of cancer, such as, skin attachment, nipple retraction, breast elevation, peau d'orange or irregularity of the breast contour: (1) traumatic fat necrosis, (2) plasma cell mastitis, (3) chronic lactation mastitis, (4) subacute inflammatory mass, (5) tuberculous mastitis, (6) gumma and luetic mastitis, (7) deep abscess (occasionally), (8) cyst (infrequently)—more commonly when within the areola, (9) intracanalicular fibroadenoma (rarely), (10) traumatic mastitis and (11) benign lesions, such as fibroadenoma or papillary cystadenoma lying *within* the areola.[39]

Sanguineous Discharge from the Nipple.—Adair[40] made a study of 108 cases in which there was a bloody discharge from the nipple and found cancer to be present in 47.2 per cent and a benign condition in 52.8 per cent.[41]

Lee says,[42] "A discharge of *blood from the nipple*, in a woman fifty years of age or over, is a highly significant sign, and I believe that in 60 or 70 per cent of the cases in this age group, cancer will be revealed after mastectomy." Wainwright[43] believes that bleeding is not sufficient alone to warrant the presumption that the lesion responsible for it is either malignant or benign. Statistically, the chances of a malignant or benign lesion are about even. The most common benign lesion causing bleeding is duct papilloma. This author believes that in cases of bleeding of the breast which has occurred continuously or intermittently for a month, safety demands removal of the bleeding tissue. If a palpable tumor is found, local excision may suffice. If several tumors or a diffuse thickening can be felt or if no tumors can be demonstrated, the entire breast should be removed. Babcock[44] has described a simple and ingenious operation for the excision of an isolated milk duct in cases of discharging nipple. All patients, however treated, should be kept under careful observation.

Paget's Disease of the Nipple.—In this condition, which occurs chiefly in women over 40, the skin of the nipple and the area around it becomes reddened, and desquamation occurs. "Infiltration soon produces a bright red, granular, indurated surface, with a sticky yellowish discharge which, by forming crusts, may obscure the nature of the lesions save at the border, which continues to be characteristic—sharply defined, indurated, and sometimes distinctly raised."[45] It is known that cancer of the breast will follow Paget's disease of the nipple, and by some[46] it is believed that Paget's cells [illegible]

[illegible] nd in regions

[illegible] *is the result* of the invasion of the epidermis of the nipple by tumor cells of glandular type which reach it from the upper extremities of the lactiferous ducts affected by neoplastic disease. These tumor cells constitute the 'Paget cells.' Their growth is intra-epidermal." Once the diagnosis of Paget's disease of the nipple is made, prompt and total removal of the breast is indicated.

In their article Eller and Anderson[49] state: "Our observations in these cases substantiate the reports of Cheatle, Pautrier, Fraser, and others who gave cogent reasons for removing Paget's disease of the nipple from the

realm of the so-called 'precancerous dermatoses' and putting it in the class of a true cancer.

"Paget's disease of the nipple is most frequently seen in women over forty and is usually unilateral. Most often it begins as a mild eczematoid condition of the nipple which may spread over the areola and even part of the breast. Later it may become ulcerated or erosive. In the more advanced stage there may be retraction of the nipple. Occasionally before any dermic lesion is seen, a serous exudation may be present on the nipple as a forerunner of what is to follow."

These authors conclude that Paget's disease is a true cancer which most probably is an epithelioma that has arisen in the first milk ducts near their mouths. They "are strongly of the opinion that Paget's disease should never be considered a precancerous lesion but always a carcinoma of the nipple, *symptomatic of deeper carcinoma of the breast, and that early and total removal of the mammary gland is always indicated.*"

Cohn[50] says, in part: "1. There may be no difference clinically between a small, apparently insignificant lesion of the nipple which is benign and one which under the microscope shows fully developed Paget's carcinoma. When such a lesion does not heal in a few weeks by simple cleansing and protective measures, a biopsy should be performed. 2. The biopsy for a lesion on the nipple should consist of complete excision of the nipple, the areola and the central zone of the breast beneath. 3. *Fully developed cancer of the nipple may be present without the presence of a fissure or an ulcer.* There may be only slight keratosis surrounded by an area of irritation, the entire apparently innocent lesion being confined to the nipple only. 4. When microscopic study of the sections made from the tissue removed for biopsy shows Paget's carcinoma, *operation for complete removal of the breast should follow.* . . ." West and Nickel[51] have reviewed the records of 20 cases of Paget's disease [illegible] from the clinical point of view there appear [illegible] ment; and (2) those which, from the first, apparently present a carcinoma of the breast with secondary invasion of the nipple, and in which the prognosis is poor. Metastasis occurs in both groups, more frequently in the second than in the first.

Blue-Domed Cyst.—McGlannan[52] says that "the clinical signs of blue-domed cyst are fairly distinct, and usually the diagnosis can be made with a reasonable degree of accuracy. The tumor is superficial, often fluctuates, and is not fixed to the tissues. The surrounding breast is lumpy rather than shotty, and it is rare to find dilated ducts beneath the nipple. Transillumination of the breast shows a clear area in the position of the tumor. Often the tumor is painful or tender, and there is a history of a variation of its size at different times. Sometimes there is a clear history of the spontaneous disappearance of a similar tumor followed by the development of the one under investigation." Inasmuch as *cancer occasionally develops in these cysts,* according to McGlannan,[52] it "is better to excise all blue-domed cysts and to study the surrounding breast tissue as well as the wall of the cyst for areas of malignancy."

Treatment of Breast Tumors.—Although the usual signs which ordinarily would suggest malignancy, dimpling of the skin, enlargement of axillary lymph nodes, loss of weight, etc., are absent, it is of extreme importance to remove all lumps, with a small portion of the surrounding tissue, from the breast for definite microscopic diagnosis. It is impossible to exclude the diagnosis of carcinoma by palpation. The proper procedure in cases of this

type is to inform the patient that she or he has a tumor of the breast which most likely is benign but which should be removed for purposes of protection because of the impossibility of making a positive diagnosis without the aid of the microscope. In every case it will be necessary to secure from the patient consent for radical amputation of the breast in case malignancy is uncovered in the local removal of the nodule. *Whereas the removal of a small adenoma from the breast under local anesthesia is in itself a distinctly minor surgical procedure, the fact that not infrequently it is necessary to continue the operation and under the same anesthesia go on to a radical amputation removes from the field of minor surgery all tumors of the breast.* The patient will be anesthetized with ethylene anesthesia and the nodule quickly excised. Without permitting the patient to awaken from the anesthetic the excised tumor is submitted to the pathologist for an opinion (*biopsy*). Generally he will have to make a frozen section to determine the nature of the growth. On assurance that the growth is benign, the surgeon, who has previously obliterated the dead space with buried catgut sutures and has closed the small wound with interrupted silk sutures, will allow the patient to come out of the anesthetic. If, however, the growth is pronounced malignant, he will proceed to do a radical operation. In the event that the pathologist is unable to make a positive diagnosis either from the gross appearance or from frozen section, the decision as to whether or not a radical operation is necessary will have to be deferred until paraffin sections have been completed.

Ewing[53] emphasizes the importance of not performing a biopsy unless the surgeon is prepared to have an immediate accurate diagnosis of the tissue and is prepared to do an immediate radical operation.

Inguinal Endometriosis

It has been observed that under rare circumstances there may be found in the inguinal region, either with or without an inguinal hernia, a tender mass of variable size which has the propensity of becoming swollen and painful at the time of menstruation or when menstruation should occur in cases of hysterectomy. The explanation of this unusual condition is thought to be that small bits of endometrium escape from the tubes into the peritoneal cavity. There they may become secondarily implanted and may grow and exhibit much the same characteristics as the normal endometrium. They may become attached to the base of the inguinal hernial sac and thus bring about a painful nodule.[54]

Malignant Tumors

The malignant tumors belong in general to the realm of major surgery.

Hertzler[55] has called attention to the importance of the early *recognition of fibrosarcomatous tumors of the skin.* If the tumor is completely removed together with its capsule a permanent cure is assured. A tumor of this type grows slowly and metastasizes by way of the lymphatics. Its summit is covered by an attenuated skin with a reddish or pinkish color which resembles the covering of a spina bifida. In some instances the [illegible]

[illegible] Hertzler finds fibrosarcomatous tumors of the skin situated most frequently on the trunk, particularly about the groin and buttocks. They are completely encapsulated except over the surface, where the skin is attached to them. If they have not begun to invade the surrounding tissues they glide over the deep fascia. On palpation they are found to be firm, dense and elastic. The cut surface shows wavy bundles more or less parallel with each other. The surface is pearly or pinkish and glistening. The cells of the tumor are spindle shaped and arranged in more or less parallel bundles. When the tumor begins to develop rapidly it invades the surrounding connective tissue. It first spreads

into the skin surrounding the summit and later becomes attached to the surrounding tissues. In all metastatic areas, it retains its fibrotic character. The peculiar relation of the skin to the surface of the tumor reveals the character of the growth at a glance. A wen is less firm, and a lipoma which becomes attached to the skin causes no skin changes. Gummas lack the encapsulation and have a shorter duration. Angiomas differ in density. The treatment is complete excision of the tumor together with its capsule well into the normal tissue.

CONGENITAL AND ACQUIRED DEFORMITIES OF THE TRUNK

Congenital Deformities

Pilonidal (Sacrococcygeal) Cysts and Sinuses (Postanal Dermoid).— Pilonidal (hair nests) cysts are congenital cysts which are found at the base of the spine in the region of the sacrum. Kooistra[56] has found in the literature reports of 13 cases of pilonidal sinuses occurring at spinal segments higher than the sacrococcygeal region, and he describes another case in which the sinus was over the third dorsal vertebra. Pilonidal sinuses in identical twins have been reported.[57]

Fox,[58] after careful study, concluded in part that a "pilonidal sinus is a derivative of skin ectoderm and not neurogenic or enteric in origin," and "that the structures forming the sinuses are derived by a process of ectodermal invagination from the skin surface at the time and in the cells destined to form skin appendages (hair and glands) during the third and fourth months of embryonic life." Newell[59] believes that it is probably the result of traction on the skin caused by retrogression of the tail bud in embryonic development. According to McKirdie,[60] "the theories of origin are confined chiefly to whether the cyst or sinus arises from the neurenteric canal or is the result of ectodermal invagination." He believes the former theory to be more tenable. According to Gage,[61] some pilonidal sinuses enter the sacral canal, and some even are continuous with the central canal of the spinal cord or open into the subarachnoid space. In the latter small group, cerebrospinal fluid is discharged from the external opening of the sinus. Zieman[62] describes a rare case of pilonidal cyst with a sinus tract which was "in direct communication with the linings of the sacral canal." Shenkin et al.[63] have reported on a pilonidal sinus which was in direct continuity with the central canal of the spinal cord. They believe that this is evidence that pilonidal sinuses "originate as a malformation in the development of the neural canal." Rogers and Dwight,[64] in a personal experience with some 400 patients with pilonidal sinus, have never seen one communicating with the neural canal, nor have they seen one extending into the sacrococcygeal joint or beneath the sacral aponeurosis.

Pilonidal cysts and sinuses may contain hair and most frequently communicate with the skin by means of one or more small fistulas or sinuses. The opening of the sinus or sinuses is generally in the midline between the tip of the coccyx and the anal canal and runs upward toward the lower end of the sacrum and coccyx. When the opening is not in the midline there is generally a well marked depression at this point, and the existing sinus or sinuses are the result of previous operations or secondary infection in the cyst. In some cases this sinus may have its orifice very close to the anus and will simulate a fistula-in-ano. In other cases the orifice will be much higher. In many cases there are multiple openings which communicate with a cystlike cavity. Eisenklam[65] calls attention to the frequency of errors of diagnosis. In only 10 of the 80 cases in the First Surgical Division of the Vienna General

Hospital was the condition diagnosed correctly. The incorrect diagnoses included furuncle and abscess, caries of the coccyx, and fistula and periproctitis. A roentgenogram made after the injection of lipiodol into the sinus is often helpful in estimating the extent and direction of the tract.[61] A probe, gently inserted into the tract, will help show the direction.

Stone[66] says: "The clinical importance of these sinuses arises from the fact that they are prone to infection and that once infected they give recurrent trouble until radically removed. As a rule the patient is unaware of the existence of this lesion until infection takes place, which usually occurs from the eighteenth to the twenty-fifth year of life. After infection, it is usual to find lateral orifices discharging pus and lined with granulation tissue which may distract attention from the original congenital opening."

During World War II, owing to the fact that a large number of men were rejected for military service because of pilonidal sinuses, fresh interest was

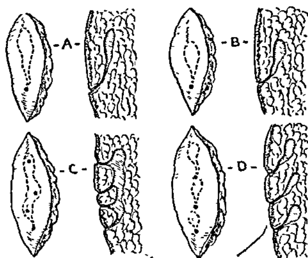


Fig. 226.—More common types of gross pilonidal sinus structure. *A*, most common *type with one natural sinus, long tract and well developed cul de sac.* [illegible] and short tract with large cul-de-s[illegible] cul-de-sac. *D*, three "independent" [illegible] South M. J. 34: 1156, 1941.)

aroused in this subject. Many of these men were entirely unaware that they had a pilonidal sinus until a physical examination was made. Throughout the war, pilonidal sinuses caused a great deal of disability and loss of time. Buie[67] gave the name "*jeep disease*" to the condition activated in a quiescent sinus by riding in a jeep, truck or tank.[68]

Treatment of a Pilonidal Sinus or Cyst.—(*a*) The acutely infected pilonidal sinus or cyst may develop into a very painful abscess in which the overlying skin is red, indurate and painful. No attempt at excision should be made under these circumstances, but the abscess is generously incised and loosely packed with vaselin gauze and Penrose tubing. As the packing is removed, the wound should be carefully dressed until it is entirely healed. The draining inflamed sinus may require incision or at least warm fomentations until all tenderness and redness have disappeared.

(*b*) The non-inflamed pilonidal sinus or cyst, in the writer's opinion, requires excision and primary closure. General anesthesia is preferable to

local anesthesia. The patient is placed prone on the operating table, with the buttocks elevated and spread apart by means of adhesive plaster. After preparation of the skin and draping, the sinus or sinuses are gently injected with methylene blue, a blunt-tipped, flexible fistula needle being used. An ellipse including all the sinuses is then excised down to the sacrococcygeal fascia. Care is taken to avoid cutting into any of the methylene blue injected sinuses, proximity to which can be recognized by the darker color of the tissue. All bleeding is meticulously controlled with fine silk ligatures, and the wound is lightly frosted with sulfathiazole. The dead space is obliterated with buried silk sutures, and the skin is closed with silk. After a large gauze dressing has been applied, the buttocks are snugly approximated with adhesive plaster. Sutures are removed on the fifth to seventh day, and the strapping is replaced for five to seven days more as a prophylaxis against wound dehiscence.

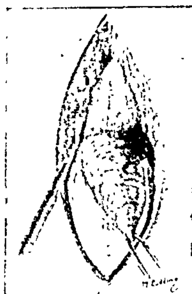


Fig. 227.—Excision of sinus tract and margin of normal fat from the sacrococcygeal fascia. (Dunphy, J E., and Matson, D. D.: Surg , Gynec. & Obst. 75: 737, 1942.)

Woldenberg and Sharpe[69] report 100 consecutive cases of pilonidal disease in which the patients were treated by means of excision, local applications of sulfathiazole or sulfanilamide and primary closure. Seventy-two per cent of the patients had completely

[illegible]

Infected cysts were incised and prepared for excision. Scott excises the minimal amount of skin and subcutaneous tissue necessary to remove the diseased-parts One-half to one and one-half grams of a sulfonamide is sprinkled into all parts of the wound cavity, dead space is obliterated by suture, the skin wound is closed and sulfonamide is dusted on the surface. Buffered sulfanilamide is preferred. In the 29 cases in which no drug was used, primary [illegible] in 72 per cent of the cases; in 5 cases in which sulfathiazole was used, [illegible] 32 cases in which sulfanilamide was used, [illegible] in 28 cases in which buffered sulfanilamide [illegible] sing a similar method, Camp and Polites[71] [illegible] r cases of complete closure. After studying

240 cases of pilonidal sinus or cyst, Burns[72] says that the most effective type of operation is that of leaving the wound open for granulation. In a review of 300 cases, Raider and Andrews[73] advise *primary* closure and do not advocate the use of sulfanilamide. Larkin[74] obtained primary healing in 90.9 per cent of 66 cases not previously operated on by radical excision, primary closure and penicillin therapy. Larsen[75] reports primary healing in 96.9 per cent of 225 consecutive cases with primary closure. Dunphy and Matson[76] undercut the fat to help obliterate the dead space and emphasize the superiority of silk over catgut. Weeks and Young,[77] in reporting 200 cases, have found primary closure to be the treatment of choice. Brezin[78] advocates a U-shaped incision placed transversely.[79]

In reporting 350 cases of pilonidal sinus, Kooistra[80] says: "Treatment remains an individualized problem. Incision and drainage are indicated in all cases of acute infection. Carnoy's solution following incision has merit in selected cases. Excision with primary closure is advisable in the comparatively uninfected and less extensive lesions. Excision and open packing is indicated in the more severe and recurrent lesions. The end results of all methods of treatment leave something to be desired. A prolonged healing time and recurrence of the lesion are common problems. The suture material used in the closure of wounds is important; silk is preferable to catgut."

Pope[81] has devised an operation for pilonidal sinus in which a sliding muscle graft is obtained by gluteus maximus cleavage mobilization. Penicillin and sulfonamides are used in conjunction. Complete healing occurred in all of the 92 cases in which this method was used.[82] The Pope operation, slightly modified, is given strong endorsement by Holman.[83] Burch and his associates[84] have had excellent results from turning in a flap of gluteus muscle on each side to obliterate the dead space. Silk, meticulous hemostasis and pressure dressings were helpful. Healing occurred in nineteen days in 100 per cent of 21 cases.

Colp[85] advises block excision after injection with methylene blue and primary suture without drainage. A similar closure is described by Van Alstyne.[86]

Partial closure, after excision of a pilonidal sinus, is advocated by De Prizio[87] and MacFee.[88] Packing the wounds wide open is advised by Pickett and Beatty,[89] Heyd[90] and Tendler. Scott[70] says more tender, vulnerable scars result from this method, to say nothing of prolonged healing.[91]

Buie[92] describes his marsupialization operation for pilonidal sinus as follows: "A probe or grooved director is inserted into the sinus, and the overlying tissues are split. If multiple sinuses are present, each is treated in this manner until all subsidiary tracts and the entire cavity have been opened. The overhanging edges of skin, along with the external and lateral walls of the cyst and sinuses, are cut away, leaving intact the inner wall of the cyst and its branching tracts. It is not possible always to utilize all of the wall of the lesion. Sometimes it is not situated so that it can be made to fit properly. Then the technic is modified to suit the occasion and it may be necessary to suture the skin edge to the aponeurosis of the sacrococcygeal region, the gluteal muscle, the thickened fibrous integument usually found adjacent to inflamed pilonidal lesions, or even to the fat. Although such alternatives are not desirable, they have not defeated the purpose of the operation. Usually, the edges of skin can be sutured to the margins of the remnant of membrane which originally enclosed the cyst and sinuses. Even in those unusual cases in which involvement is extensive, or when it is considered advisable to remove the coccyx, portions of the membrane can be preserved with advantage.

Postoperative dressings and general care of the patient do not differ from those used in the care of other patients."[93]

Theis and Rusher[94] use a modified partial closure. This consists of "(1) block excision of the pilonidal cyst and sinus, (2) tension sutures which include the presacral fascia, (3) primary closure of the subcutaneous tissue with interrupted sutures and (4) separation of the skin edges to delay healing of the skin by means of vaseline iodoform gauze placed between the edges.* The delay in skin healing permits escape of wound secretions until firm union of the subcutaneous tissue occurs, thus preventing hematoma formation or serum collections within the wound." In 37 cases so treated the average healing time was 26.6 days.[95]

In 1935 Rogers and Hall[96] reported their conclusions after further studies of these cases. They believe that the injection of a dye for guidance in dissection may be harmful and that "on morphologic grounds there are no indications for radical excision." These authors employ the method of Stanton[97] and describe it as follows:

The operation is performed under local infiltration anesthesia, but only the skin along the midline is anesthetized so that there is no disseminating of infection into sound tissues. The cutting is done entirely with a cautery knife; this method provides a bloodless field which facilitates the recognition of unstained diseased tissue, not only by its appearance but by the fact that such tissue is less readily divided by the cautery knife than is normal fat The diseased tissue is first completely divided longitudinally down to the sacrococcygeal fascia and is then removed in halves by slightly undercutting the edges of the skin. The resultant narrow cavity is packed, and the patient is allowed to go home. This procedure has proved to be a minor operation producing no systemic reaction Not only is hospitalization avoided, but the patient remains ambulatory throughout, and the total time lost from work may be as little as half a day.

"At first glance it appears that dead space must result from the failure to remove any skin. This would undoubtedly be the case were it not for the careful application of postoperative dressings which rivals in importance the operation itself. Each time the wound is dressed the floor of the cavity is scru inized, and any unhealthy-looking area of granulation tissue is painlessly curetted down to a solid base or excised with the cautery knife. By this method of fractional operation whatever diseased tissue may have been overlooked at operation is recognized and removed during the period of healing. The cavity is kept packed until it has been obliterated by the growth of healthy, solid granulation tissue, which then appears as a narrow coxcomb between the two edges of skin. It is important to keep this coxcomb down to the level of the surrounding skin until the whole surface has become epitheliated The end-result is a linear midline scar"

For further details as to the dressings the reader is referred to the original article. These

recovered at the time the article was written was 2.7 months.

Umbilical Sinus and Cyst.—Remnants of the urachus may bring about the formation of sinuses or cysts at the umbilicus. If the bladder end of the sinus is closed, the discharge will consist only of epithelium and sebaceous material. In these cases a cure may be obtained by swabbing with pure phenol or excision under local anesthesia. Where the urachus becomes closed at both ends, a cyst may result. Where the urachus is patent throughout,

A patent omphalomesenteric duct may be the origin of an intestinal fistula at the umbilicus. Its treatment is a major surgical problem.

Dr. Vernon David,

Patent urachus, or *vesico-umbilical fistula*, is an unusual condition. Mast *et al.*[101] say: "The urachus may be ligated at its upper extremity. This procedure is more applicable in early childhood. Cauterization of the upper portion of the tract may sometimes cure the condition. This may be accomplished by passing a small probe-pointed thermocautery directly into the canal.

"If the simple methods fail, radical extirpation of the entire urachus and umbilicus must follow. Mayo dissects out the tube thoroughly. The duct is then ligated, excised and the stump inverted by a purse-string suture and a drain is left in the bladder. In case a patent urachus exists without the formation of a vesico-umbilical fistula, excision is performed in exactly the same manner."

Congenital Deformities of the Nipple.—*Congenital absence of the nipple* (*aphelia*) requires no surgical treatment.

[illegible]

logic condition of the breast.

Congenital Deformities of the Breast.—*Amastia*, absence of the breast, and *micromastia*, minute breast, require no surgical treatment. *Polymastia*, multiple breasts, will require surgical intervention. Such breast tissue as seems superfluous will be removed and an effort made to convert the remaining tissue into a breast of normal appearance. De Cholnoky[102] says that "accessory breasts are commonly observed (1 to 2 per cent) in both sexes and are usually situated in the milk lines. . . . No operation is indicated for these anomalies unless there are 'psychologic' symptoms or unless their location or tumor formation warrants removal."

Congenital Absence of the Pectoral Muscles.—Partial or complete absence of one or both pectoralis major and minor muscles[103] has been reported frequently. The disability in the absence of pectoral muscles is extremely slight, and there is no treatment.

Spina bifida, meningocele and myelocele are congenital deformities originating from incomplete closure of the vertebral arches with a varying amount of protrusion of the spinal cord and cauda equina upon the surface of the back. The condition may vary from a mere colored dimple over the spinal column to a large rounded swelling and even to an open sinus from which spinal fluid discharges. The treatment will be major surgical.

Coccygeal Glomus.—Reuther[104] has studied the coccygeal glomus and believes it to be a possible factor in coccygodynia.

Os Acromiale.—Liberson[105] says that roentgenographic examinations of 1,800 shoulder

[illegible]

Acquired Deformities

Hernia.—*Umbilical hernia* may be congenital but generally is acquired. It is manifested by protrusion at the umbilicus which is apparent when the infant cries. This protrusion may attain considerable size. The palpating finger on the abdominal wall will appreciate a firmly demarcated ring at the umbilicus. This ring may be as small as ¼ inch in diameter or considerably larger. Practically all umbilical hernias in infants will yield to mechanical or truss treatment. For this purpose a rigid hemisphere* whose convex side is applied to the hernial ring after the hernia has been reduced will be useful. The hemisphere is kept in place by a band of adhesive plaster which is wider than the diameter of the hemisphere and which completely encircles the infant's body. The parents will be instructed to replace this apparatus at intervals to insure the good condition of the underlying skin. It may be necessary to persist in this type of truss for six months to a year and in some cases even longer before a cure is effected. If truss treatment is unsuccessful

* The half of a wooden ball found in a child's ten pin set will be very suitable.

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For further details as to the dressings the reader is referred to the original article. These patients are ambulatory, and in 50 cases the average postoperative hospitalization was one day or less, and the average time lost from work was one week. There have been no known failures or recurrences. The average time required for healing in the 29 patients who had [illegible]

[illegible] ation [illegible] harge [illegible] tained [illegible] is becomes closed at both ends, a cyst may result. Where the urachus is patent throughout, urine will be discharged from the sinus In the latter 2 cases the treatment is major surgical Smith[98] reported a small umbilical cyst which had become strangulated and which required [illegible] granuloma of this region [illegible] its removal Adenoma[99]

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[illegible]

logic condition of the breast.

Congenital Deformities of the Breast.—*Amastia*, absence of the breast, and *micromastia*, minute breast, require no surgical treatment. *Polymastia*, multiple breasts, will require surgical intervention. Such breast tissue as seems superfluous will be removed and an effort made to convert the remaining tissue into a breast of normal appearance. De Cholnoky[102] says that "accessory breasts are commonly observed (1 to 2 per cent) in both sexes and are usually situated in the milk lines. . . . No operation is indicated for these anomalies unless there are 'psychologic' symptoms or unless their location or tumor formation warrants removal."

Congenital Absence of the Pectoral Muscles.—Partial or complete absence of one or both pectoralis major and minor muscles[103] has been reported frequently. The disability in the absence of pectoral muscles is extremely slight, and there is no treatment.

Spina bifida, meningocele and myelocele are congenital deformities originating from incomplete closure of the vertebral arches with a varying amount of protrusion of the spinal cord and cauda equina upon the surface of the back. The condition may vary from a mere colored dimple over the spinal column to a large rounded swelling and even to an open sinus from which spinal fluid discharges. The treatment will be major surgical.

Coccygeal Glomus.—Reuther[104] has studied the coccygeal glomus and believes it to be a possible factor in coccygodynia.

Os Acromiale.—Liberson[105] says that roentgenographic examinations of 1,800 shoulder girdles in the sagittal plane disclosed 21 typical and 4 atypical cases of os acromiale. At least 6 of these cases have been contested as being possible fractures. An additional study of 1000 cases gave a frequency of 2.7 per cent, 62 per cent being bilateral. A superoinferior examination facilitates the making of a differential diagnosis.

ACQUIRED DEFORMITIES

Hernia.—*Umbilical hernia* may be congenital but generally is acquired. It is manifested by protrusion at the umbilicus which is apparent when the infant cries. This protrusion may attain considerable size. The palpating finger on the abdominal wall will appreciate a firmly demarcated ring at the umbilicus. This ring may be as small as ¼ inch in diameter or considerably larger. Practically all umbilical hernias in infants will yield to mechanical or truss treatment. For this purpose a rigid hemisphere* whose convex side is applied to the hernial ring after the hernia has been reduced will be useful. The hemisphere is kept in place by a band of adhesive plaster which is wider than the diameter of the hemisphere and which completely encircles the infant's body. The parents will be instructed to replace this apparatus at intervals to insure the good condition of the underlying skin. It may be necessary to persist in this type of truss for six months to a year and in some cases even longer before a cure is effected. If truss treatment is unsuccessful

* The half of a wooden ball found in a child's ten pin set will be very suitable.

or impracticable, surgical treatment should be resorted to, as it is not hazardous and is almost always succesful.

Inguinal Hernia.—(*a*) *In Young Children.*—Inguinal hernia in young children is a rather common condition and up to the age of three years may be treated and very often cured by the use of a truss. For young infants, up to about 6 months of age, a yarn truss is very useful. The truss is made by tying knots in yarn so as to make a sizeable yarn ball, which is placed over the hernia to maintain it in reduction and is held in place with yarn bands around the waist and perineum. If a metal truss is used, it is of considerable importance to have it properly made and fitted. One with a steel band and leather pad with pressure over the inguinal ring is the best type. Once the surgeon has fitted the truss so that continuous pressure of the pad is maintained over the ring, he must spend considerable time in instructing the parents or attendants as to its care. The truss will have to be removed daily when the child is given its bath and the skin washed with alcohol and thoroughly powdered. Should abrasions or infections arise, it will, of course, be necessary to discontinue the use of the truss temporarily. When the truss is reapplied after the bath, the infant should be lying flat on his back and particular effort should be made to be assured that the hernia is reduced.[106]

Many parents will prefer to subject their child to an operation which carries but very low mortality and morbidity rather than to spend many months in the painstaking care that a truss requires, especially since that method is not a certain cure. The operative treatment for hernia is ordinarily considered to be a major surgical problem.

(*b*) *In Adults.* Many adults will decline operation for hernia, and in patients of advanced age or with cardiovascular disease operation may be contraindicated. In these cases it will be incumbent upon the surgeon to see that his patient is properly fitted with an efficient truss. After the patient has been referred to a trussmaker in whom the surgeon has confidence, he will again be seen and inspected. The truss must have a pad of ample size to occlude the hernial ring and must have a spring of sufficient tension to maintain the pads in position. Perineal straps occasionally will be necessary. Moreover, it is extremely important to instruct the patient in the manner of putting on and adjusting the truss and the importance of being sure that the hernia is entirely reduced before the truss is applied. All trusses are best put on when the patient is lying down.

Femoral hernia is a condition requiring major surgical treatment except in those cases in which there is contraindication to operation. In this event a truss will be fitted in the manner described.

Ventral hernia, hernia of the linea alba and *strangulated hernias* of all kinds require major surgical treatment. In cases of recent incarcerated hernia it will be justifiable to employ taxis in an effort to secure reduction. It must be emphasized, however, that prolonged and rough efforts to reduce the hernia manually are productive of far more harm than surgical intervention. Taxis should never be persisted in after a few gentle efforts.

Injection Treatment of Hernia.—In the last few years an extensive literature dealing with the injection treatment of hernia has accumulated. The method has been carefully examined by many thoughtful surgeons, and it is fortunate that this procedure, which formerly was in the hands of quacks, has now been subjected to critical and well controlled studies. There are surprising

discrepancies in its evaluation, but it would seem that its usefulness has a smaller place than it was thought to have a few years ago. The injection treatment of hernia is not simple and requires more skill than the surgical treatment; it can be mastered only after long practice. A very careful study of the subject is that of Harris and White,[107] who followed 236 patients for from six months to three years after the completion of the treatment. "There were 57 per cent of cures, 28 per cent of possible cures and 15 per cent of complete failures." There were no serious complications or deaths. The most favorable subjects are young persons with recent hernial development. The average number of office visits was 23, and the average length of time of active treatment was 5.1 months. They regard the selection and application of the truss as the most important single factor in the technic. They conclude: "In general, the end results of the treatment of hernia by injection are not comparable to those obtained by operation. These results, however, are sufficiently good to recommend this treatment when operation cannot be considered because of economic, personal or physical reasons." Burdick and Coley[108] carefully followed 56 patients who had been given injection treatment and found the rate of failure to be 81 per cent. There were possible cures in 19 per cent and probable cures in 3.4 per cent. On the basis of this study, Burdick and Coley have definitely decided to abandon the method entirely at the Hospital for Ruptured and Crippled in New York. Higinbotham,[109] who reports 78.4 per cent of failures in 56 cases, believes that there are few cases in which the method merits even a trial. Recurrence took place in 18 of 20 cases treated by the injection method and reported by Slater.[110] Injection under operative visualization is deemed by Arnheim and Neuhof[111] "to be too uncertain in results to be advocated as a dependable therapeutic procedure." Berne[112] reports 2 deaths due to injections in the course of treatment of inguinal hernia. In the first case, perforation of the ileum was found at laparotomy, and death resulted from peritonitis. In the second case, after "an initial syndrome suggesting severe irritation of the bowel wall a quiescent period occurred, with a sudden acute progressive episode five days later, probably indicating the time of perforation. These cases constitute an indictment against the teaching that intraperitoneal injection is a harmless accident and establish that laparotomy may be necessary at any time, as an emergency procedure, on the appearance of symptoms and signs indicating a significant variation from the usual clinical course following intraperitoneal injection." McDonough[113] reports a case of intestinal obstruction following the injection treatment of hernia. At operation, a loop of dilated small bowel and also a loop of collapsed bowel were seen in the right lower quadrant. By tracing this condition distally, there was found an obstruction in the small bowel due to an adhesion which drew the bowel up and attached it to the abdominal wall at the internal ring. The bowel was constricted to about two thirds of its original size, and for about 5 cm. on either side of this constriction the musculature was greatly thickened. A second adhesion was found which connected the loops and attached them lower down to the abdominal wall below the internal ring.

In this case the entrance of the sclerosing solution into the peritoneal cavity produced adhesions which caused the intestinal obstruction. Ross[114] discusses the dangers and difficulties of the injection treatment of hernia. Two patients had a severe generalized reaction; one of these patients had

coronary thrombosis, and death ensued. Serious abdominal pain occurred in several cases, probably owing to leakage of some of the solution into the peritoneum. A severe localized reaction may occur. In consultation Ross saw a patient with an abscess at the site of the injection. Swelling of the cord occurred in a few cases, and hydrocele was seen after injection treatment in 2 cases. Ross points out the possibility of injury to the bowel or bladder.

In the third edition of "Minor Surgery" a description of the technic of the injection of hernia was included. However, despite its enthusiastic advocates, this type of treatment can no longer be recommended; hence, the description is omitted here. As Maier[115] says: "The injection treatment has no place in the treatment of hernia and its use should be condemned."

Trusses.—All physicians should have some familiarity with different types of trusses and their technic of application. As space does not permit a discussion of this important subject, the reader is referred to a detailed and valuable article by Harris and White.[116]

Esophageal Varices.—Successful injection of esophageal varices with sclerosing solutions has been reported by Moersch[117] and by Welt and Blatteis.[118]

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CHAPTER XV

THE MALE GENITOURINARY ORGANS

INJURIES

Contusions of the External Genitalia.—The penis, scrotum and testicles may be subjected to contusion by blows and by falls astride hard objects. Kicks and missiles, such as baseballs, are also liable to bring about these injuries. Contusions of the penis are particularly liable to occur by compression of that organ across the rami of the pubis in falls astride hard objects. In contusions of the penis the effusion of blood into the corpora cavernosa may be very marked, and there may be considerable swelling and a great deal of pain. When accompanied by rupture of the tunica albuginea, the injury is termed *rupture of the penis*. In marked cases the swelling will be so great as to interfere with the patency of the urethra, and acute retention of urine will result. If the urethra is torn without free opening to the outside, extravasation of urine will occur, a serious condition not uncommonly followed by superficial gangrene and requiring major surgical treatment. The proper treatment of contusions of the penis is bodily rest, elevation of the penis and hot or cold fomentations. Senger[1] advises incision, ligation and suture of the sheath if the effusion persists.[2] The treatment of a coincident retention of urine will be discussed presently.[3]

Contusions involving the scrotum and its contents are particularly painful because of the extreme sensitivity of the testicle. The tunica albuginea being relatively inelastic, hemorrhage and edema inside of the testicle may cause extreme pain.[4] The treatment consists of rest, elevation and hot fomentations. In some cases contusions of the scrotum itself will cause a very marked hemorrhage into the scrotal sac, which will become enormously distended with blood, and the condition of hematocele will result. Symptomatic treatment, such as elevation and fomentations, will bring about the gradual absorption of this blood, but when the effusion is very marked it will be necessary to remove it with an aspirating needle or trocar or through a small incision. Formal operation with ligation of the bleeding vessel may be necessary. In the milder cases, with the patient ambulatory, the scrotum will be firmly compressed by means of an elastic suspensory. In many injuries of the testicle, atrophy follows.[1] Intratesticular hemorrhage occurs as a birth trauma in perhaps as high as one third of the cases.[5] Baker and Evoy[6] advise prompt decompression in the event of postoperative swelling of the testicle. Girdansky and Newman[7] successfully implanted a hollow vitallium mold to replace an absent testicle. Neuhof and Mencher[8] state that severance of the spermatic cord between the external and internal abdominal rings has "little or no apparent effect upon the testis or epididymis in the majority of cases if a careful technique is employed." These authors have excellent illustrations of the various anastomoses between the spermatic, cremasteric and deferential arteries.

Rupture of the Urethra and Bladder.—*Rupture of the Urethra.*—Rupture of the urethra generally occurs in the bulbous portion following a fall astride a hard object.

Culver[9] says: "The clinical picture varies with the extent of the injury. Minor degrees of urethral rupture, when encountered early, may present a patient with slight but constant urethral bleeding from the meatus associated with excruciating perineal pain; there may or may not be any interference with urination. Examination of the perineum will show only slight swelling or none at all. This same patient several hours later may have urinary retention caused by local edema and periurethral hematoma, while the perineum presents an ecchymosis of the skin and a semifluctuating mass. The local pain remains constant or is increased by pressure from hematoma.

"Such a patient seen early, without severe urethral bleeding and with no apparent interference with urination, should be treated with morphine, ice packs locally and frequent observation. There is no indication for attempting to pass a urethral catheter; it only increases the possibility of local infection, which is sometimes a factor which determines whether conservative management shall be continued or surgery becomes necessary. Under conservative management the development of an appreciable perineal hematoma

"Obviously those patients with interference of urination, perineal hematoma and an impassable urethra are at once in need of surgical treatment. There are many variations of clinical pictures between these two extremes and, while conservatism is a desirable trait when local conditions are understood and clinical progress is evident, procrastination often results in the loss of valuable tissue. Early surgical treatment is the only way devitalized urethral and periurethral tissues can be saved.

"These lesions are distal to the urogenital diaphragm and therefore should be surgically approached through the perineum. An external urethrotomy is made, hematoma removed, and a catheter placed in the bladder through the perineal urethrotomy. In severe urethral lacerations some difficulty may be encountered in recognizing the proximal urethral opening. Some help may be had here by having a good perineal exposure, bleeding reasonably controlled, then having an assistant press over the bladder region suprapubically. Expressed urine sometimes directs the operator's attention to its outlet. This procedure has been successful for me in three patients. If this fails and a reasonably long, intelligent search has been made unsuccessfully, it is much safer surgery to do a cystotomy and retrograde sounding than to indefinitely probe and stab blindly. After the perineal catheter is placed in the bladder it may be closed suprapubically; however, a suprapubic bladder drainage tube adds safety to the operation and in my experience does not prolong the convalescence.

"Should there be complete separation of the entire circumference of the urethra, ... es for a bridge for complete repair; ... to end anastomosis of more of the ... postoperative stricture. Technical ... her at any point naturally results in dense stricture, difficult but not impossible of successful conservative postoperative management. Careful regular sounding results eventually in complete epithelization of the intervening area. Tissue transplants have not been successful."

Urethral injury which accompanies fracture of the pelvis occurs posterior to the diaphragm and requires suprapubic operation, while a straddle injury of the urethra occurs anterior to the diaphragm and requires perineal operation (Culver).

Culver continues: "Contusions of the urethra without rupture may result in urinary retention because of local edema. A catheter can be passed without much difficulty and ... urethral damage ... f an attempted catheterization. Should obstruction be met at the triangular ligament area with a soft

rubber catheter, no further attempts should be made. The use of stiff fibrous or metal catheters is condemned. These patients should receive surgical attention at once."

Urinary extravasation is a most serious complication of urethral or vesical injury. In large groups of cases the average mortality has been 40 to 43 per cent. Ockerblad and Carlson[10] have had a mortality of only 6.6 per cent in 15 consecutive cases. These authors note that urinary extravasation rarely results from complete rupture of the urethra but is more likely in cases in which there is one small break and moreover only in the presence of a stricture. In penile extravasation the urine is within Buck's fascia, and the swelling is limited to the penis. In perineal extravasation the point of rupture is anterior to the triangular ligament, and the extravasated urine collects first in the perineum but "soon extends to the scrotum and penis, and later over the abdomen, in some cases as high as the axillae." (Ockerblad and Carlson) There is no extension to the thigh. In pelvic extravasation the rupture of the urethra is posterior to the triangular ligament, and the swelling begins in the perineum and extends to the suprapubic space. In the intraligamentous type of extravasation, the injury to the urethra is between the layers of the triangular ligament, and the urine collects in this area, though it later may become pelvic, perineal or gluteal. Ockerblad and Carlson say:

"The patient complains of a sudden sharp, spontaneous pain, usually in the perineum, followed by the development of swelling and increasing difficulty in urinating. The location of the swelling depends upon the location and size of the rupture and, to some extent, upon its duration.

"In most instances there has been previous difficulty in micturition, due either to a gonorrheal or to a traumatic stricture. When first seen, the patient generally feels quite ill, and there may be complete urinary retention.

"On examination, the affected parts are at first greatly enlarged and quite tender to the touch. The patient appears toxemic and may have chills and fever. The pulse is somewhat faster than normal. The white blood count is elevated, ranging from 14,000 to 28,000 in the acute stages. The urine when first obtained contains considerable albumin. The N. P. N. and creatinine may be elevated. Later he may exhibit mental confusion progressing to delirium and coma.

"As the extravasation progresses necrosis of tissue occurs, particularly in the perineal type. There may be, therefore, darkened areas on the scrotum and the penis if the extravasation has been of sufficient duration. It is probable that necrosis is not due to the irritative properties of urine but rather to the pressure of the urine which cuts off the blood supply of the tissues.

"These patients are usually desperately ill and require prompt treatment. Their general condition has often been impaired by the antecedent urinary difficulty with its attendant loss of rest and backflow of urinary products. In addition, the patient with urinary extravasation has increased difficulty in urination from the extravasation itself, as well as imminent or established uremia, and also a severe toxemia from the absorption of the products of degenerating tissue.

"Free drainage of the bladder should be provided and adequate incisions for release of extravasated urine and of necrotic tissue should be made. It is better not to waste time in attempting to dilate the already injured urethra. To do so may add just the amount of trauma necessary to make the ending fatal. The perineal cystotomy advocated by some does not seem logical, since the insertion of a catheter into the bladder must further damage already injured and infected tissue." Finestone[11] considers suprapubic cystotomy more effectual than external urethrotomy as a means of urinary diversion in these cases. He advises multiple free incisions of the involved tissues.[12]

Rupture of the Bladder.—The bladder may become ruptured in consequence to crushing violence across the abdomen or because of unskilful instrumentation in the bladder. The condition is recognized because of absence of urina-

tion, the history of the traumatism and the negative results from catheterization. Roentgenograms made after injection of air into the bladder not only will demonstrate the presence or absence of rupture of the bladder but will also tell whether the rupture is intraperitoneal or retroperitoneal.

Torsion of the Testis.—In torsion of the testicle, that organ and spermatic cord are so twisted as to interfere with the blood supply of the testis. As Ormond[13] says:

"Although the condition is uncommon, its recognition is of considerable importance, for failure of recognition may result in a testicular atrophy which might have been prevented, and this assumes greater importance in view of the fact that in 24 of Abeshouse's[14] 350 cases the condition was bilateral. It is undoubtedly true that in some of the instances of testicular atrophy encountered in the course of routine physical examination the disease is due to previous and usually unrecognized torsion. Atrophy of the testicle is usually due to mumps, trauma (including operation for hydrocele, hernia or varicocele) or torsion. The atrophic testicle of mumps is usually soft and extremely sensitive, while that due to trauma or torsion is firm and insensitive. The undeveloped testis is small and soft but not unduly sensitive." Torsion is found at any age but is commonest in adolescence or early adult life. It is commoner in cases of maldescent of the testicle. The intravaginal type of torsion is more common than the extravaginal. A long or narrow mesorchium may predispose to an attack. Torsion of the testicle has been known to occur four hours after birth. Torsion of the hydatid of Morgagni has been reported.[15] The symptoms are those of orchitis and are less abrupt in onset than those of torsion of the testicle. The treatment is excision of the hydatid.

Ormond says: "Diagnosis presents some difficulties, especially in the first attack and when, as usually occurs, the patient is seen in one attack only.

"The onset is usually sudden and has occurred during sleep, awakening the patient. More often it follows effort or slight and seemingly inadequate trauma, such as that due to driving or bicycle riding. The pain is sharp, its intensity varying with the completeness of the twist. A history of previous similar attacks, clearing up spontaneously, is of extreme importance and almost diagnostic when obtained, and the absence of any history or symptoms of gonorrhea is important.

"General symptoms may include nausea, vomiting and occasionally shock. Usually there is no fever, though there may be a slight elevation of temperature. There is usually no leukocytosis.

"The urine is generally clear, and urinary symptoms are usually absent. The prostate and seminal vesicles usually present no abnormalities, though there is nothing to prevent torsion from occurring in a man whose prostate is infected.

"The affected testicular mass will be found drawn up toward the inguinal region and is usually exquisitely tender, often so tender, in fact, as to prevent satisfactory palpation. Determination of the position of the epididymis is of importance. Normally the epididymis lies posterior and medial to the testis, but in the case of torsion, unless the twist is through 360 degrees or any multiple of 360 degrees, the epididymis will be in an abnormal position. The degree of swelling varies and may be great enough to prevent differentiation of the parts of the mass. Therefore the position of the epididymis sometimes cannot be ascertained either because of the swelling or because of the extreme tenderness of the testicular mass On the other hand, in attacks of recurrent torsion the obstruction to circulation is not complete and the swelling may be confined to the epididymis, making recognition of its position fairly easy.

"Elevation of the scrotum is said to accentuate rather than to relieve the pain, as it does in cases of epididymitis, and Prehn called this a characteristic and almost diagnostic sign.

vas, and elevation of the scrotum relieves rather than accentuates the discomfort. Moreover, at the age at which torsion is most common, epididymitis is uncommon.

"Orchitis except as a complication of mumps and occasionally of influenza is rare; the pain is not usually severe, and the swelling, though excessive, does not involve the cord." The general symptoms of torsion are less severe than those of strangulated hernia.

"Prompt diagnosis is important, for on it may depend the health of the affected testis. Of course if the twist has been sufficient to cause infarction, délay makes no difference; but if the patient is seen before necrosis has occurred, prompt diagnosis and prompt treatment may preserve the life of the affected testis.

"The best treatment is immediate operation. The scrotum should be incised and the testicle delivered. If it is necrotic, it can then be removed; if it is not necrotic and if the twist is in the cord, the torsion can be relieved, and if it is intravaginal, the tunica can be slit and the twist reversed. In any event it is best to incise and invert the tunica and then suture the cord and testicle to the scrotal septum in such a way that torsion becomes impossible.

"*Sometimes spontaneous detorsion occurs, and sometimes manual detorsion is possible* without incisions; but in either event operation shortly thereafter is desirable to eliminate any possibility of recurrence.

"In the majority of recorded cases, necrosis had occurred and either orchidectomy was done or atrophy followed.

"In view of the fact that in twenty-four of 350 cases on record the condition was bilateral, and in view of the fact that congenital abnormalities such as might predispose to torsion tend to be bilateral, I advocate operation on the remaining testicle to prevent a like misfortune involving it." Ormond calls attention also to the fact that at operation a necrotic testicle without torsion is occasionally found. In these unusual cases, detorsion must have taken place after necrosis of the testicle occurred. It is not unlikely that moderate torsion with spontaneous detorsion may occur more frequently than is thought.

As Wolf[16] says: "There is no place for conservative treatment in torsion of the testicle even though the diagnosis is doubtful."[17] O'Conor[18] says: "In an adult where transposition of the undescended testis cannot be satisfactorily accomplished, or in any case in which necrosis, gangrene, or persistent circulatory obstruction is present, removal of the testis and the involved portion of the cord is indicated unless the patient has already passed through the period of pain and increased swelling. In this event, heat applied locally, and a week or ten days of rest and a suspensory achieve relatively the same result as orchidectomy." A case of torsion of the testicle in a 24 year old soldier is reported by Foley.[19] Riba and Schmidlapp[20] report 5 cases in soldiers aged 20, 22, 23, 22 and 20 years, respectively. They say the condition is "frequently undiagnosed, and after its occurrence only one in five testes is saved." They believe that operation within eight hours after the torsion "will usually result in a viable organ."

Dislocation of the Testis.—According to Alyea,[21] 23 cases of traumatic dislocation of the testicle have been reported. He adds 2 more.

The position of the dislocated testis depends upon three factors: (1) anatomic abnormalities, (2) obstruction to dislocation in certain directions and (3) the direction and force of the blow. The usual cause is severe injury, such as the passing of a wagon wheel over the genital and inguinal regions and other severe crushing injuries about the scrotum. It is at first difficult to diagnose the dislocation because of the acute swelling after the injury. A little later, however, the absence of a testicle from the scrotum and the presence of an ovoid tumor in another locality establish the diagnosis.

In 6 cases reviewed by Alyea, the dislocation was of the pubic type; in 5, of the superficial inguinal type, in 3, of the penile type; in 2, of the perineal type, and in 3, of the inguinal canal type. In 3 cases there was compound dislocation of the testis through the scrotal wall. In 1 case it was impossible to determine the site of the dislocated testis exactly. Compound dislocation of the testis has been reported.[22] Ockuly[23] reports a case of bilateral luxation of the testes and says that the literature contains reports of 93 cases of luxation.

The results of treatment are good.

Dislocation and Strangulation of the Penis.—Violent traumatism of the penis, particularly when erect, may cause the subcutaneous dislocation of that organ to a position under the skin of the abdomen or the thigh. Urinary infiltration will take place even if the urethra is not injured (Young). Restoration of position may be difficult without extensive incision of the integument. Strangulation of the penis occurs when a metal ring has been passed over the penis or the latter has been constricted by a rubber band or cord. In this case there is marked edema, and the disturbance of the circulation may be so marked as to cause gangrene, amputation being necessary. In most cases, however, the constricting agent may be removed early enough to permit recovery.

Wounds of the Penis.—The penis may be wounded by knives or by crushing violence. The corpora cavernosa are most frequently involved in a knife wound. The hemorrhage may be very alarming, especially if the penis is erect at the time of the injury, and will require most careful hemostasis together with efforts to reapproximate the wound edges. Severe traumatism of the erect penis may bring about laceration of the substance of the corpus cavernosum, known as "fracture" of the penis. The edema may be so marked as to cause dysuria or acute retention. The usual treatment is elevation with hot fomentations.

In certain cases of traumatism to the erect penis the frenum may be torn, and severe hemorrhage from the frenular artery may result. This condition will practically always require either clamp or ligature or the passing of a deep stitch to include the frenular artery. In all cases of wounds or contusion of the penis it will be advisable to give large doses of sodium bromide (60-80 grains a day) to control erection.

Priapism.—In this condition the penis is maintained in a state of more or less continuous erection. It is caused by injury or disease to the spinal cord, by a vesical calculus or by certain injuries of the penis. In the case reported by Keen and Shlimbaum,[24] priapism was caused by thrombophlebitis. In the neurologic cases the treatment will be symptomatic.

Burns of the Genitalia.—In ordinary burns of thermal origin involving the genitalia the same rules as laid down in the section on treatment of burns are followed. The genitalia are particularly subject to chemical burns produced by mustard gas. These very irritating burns are best treated by early mechanical removal of the mustard and bland ointments, such as vaselin and zinc oxide ointment.

Hematuria.—Hematuria never should be treated as an ailment in itself but as a symptom of more serious trouble. The causes of hematuria are numerous, and its diagnosis and treatment do not belong to the realm of minor surgery.

ACUTE RETENTION OF URINE

(See also Postoperative Urinary Retention; Retention of Urine in the Female)

In *retention of urine* there is inability to pass the urine out of the bladder; in *suppression of urine* the kidneys fail to secrete urine. Retention of urine may come about from various causes, including the following: (*a*) Hypertrophy of the prostate. (*b*) Stricture of the urethra. (*c*) Reflex disturbance following operation. (*d*) Wounds in the penis. (*e*) Acute infections. (*f*) Impacted calculus, new growth or papilloma. (*g*) Pin hole meatus. (*h*) Phimosis. (*i*) Caruncle.

If catheterization becomes necessary, it never should be done by an orderly but always by a physician who has been properly instructed.

In patients having acute retention of urine of mechanical origin, it will be necessary to attempt some type of catheterization. In hypertrophy of the prostate and in acute infections, particularly in gonorrhea (when symptomatic treatment has been ineffectual), if the lumen of the urethra is not impaired, the first attempt should be made with a No. 18 F. rubber catheter. It is quite probable that in cases of this type a large catheter will be more easily passed than a small one, because the latter is supposed to excite more forcible constriction of the urethra.

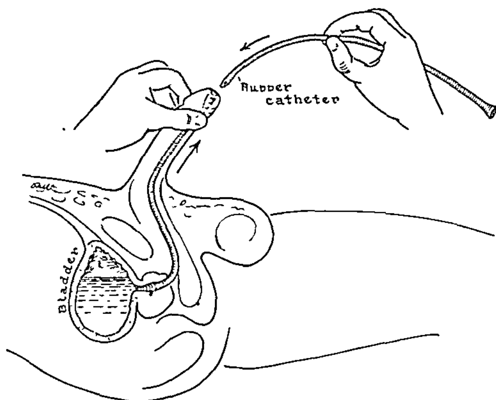


Fig 228.—Method of catheterization with a soft rubber catheter. The hands and the head [illegible] Preferably rubbe [illegible] up tig [illegible] into the urethra until the urine begins to flow.

Technic of Catheterization.—Before performing catheterization of the male the surgeon will first scrupulously clean the head of the penis with soap and water and with bichloride of mercury solution. The latter should not be stronger than 1:1000. As the last step in the cleansing the lips of the external meatus must be spread apart and the first portion of the urethra irrigated with the bichloride solution. The hands of the surgeon either should be sterilized by scrubbing and alcohol or should be incased in sterile rubber gloves. After the penis has been cleansed and sterilized with bichloride it should be laid upon a sterile sheet or gauze sponge. The catheter is then grasped about its middle portion, and the end which is first to enter the penis is thoroughly anointed with sterile abolene or sterile lubricating jelly (Fig. 228). The surgeon's *other hand now grasps the head of the penis*

immediately behind the glans and exerts an upward traction upon the penis. Morgan[25] recommends grasping the penis back of the glans between the middle and ring fingers, which leaves the thumb and index finger free to part the lips of the meatus preliminary to the introduction of the catheter. The catheter is then passed slowly and gently into the urethra. Too forcible manipulation will only excite obstructive contraction of the urethra. One of the chief factors in the successful accomplishment of catheterization is the marked degree of traction upon the penis. This maneuver straightens out the urethra and more readily permits the passage of the catheter. When the catheter has entered the bladder and the urine begins to flow the penis is lowered and the catheter placed in a proper receptacle. If a soft rubber catheter will not pass, it will be advisable to use a Mercer silk catheter, being

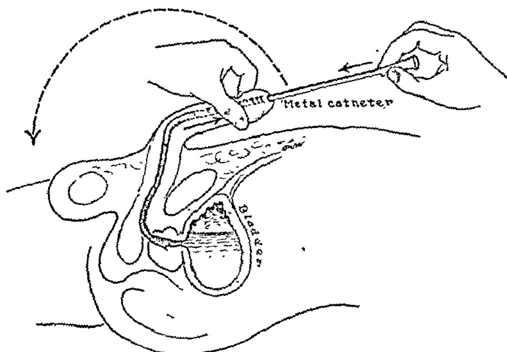


Fig 229.—Method of catheterization with a metal catheter The penis is held parallel to the surface of the body and strong upward traction is made on it as the catheter is passed. When the curved tip of the catheter has passed the base of the penis, the penis and catheter are swung over an angle of 180 degrees as the tip enters the bladder. It is occasionally necessary to guide the tip of the catheter by placing the hand against the perineum.

careful to have the tip point upward. In cases in which this fails, a curved metal catheter will be used. The same antiseptic precautions are used as have been described, and the penis is drawn up on the shaft of the metal catheter. The shaft of the catheter is held immediately above and parallel to the abdominal wall, and firm upward traction is made upon the head of the penis. With continued traction upon the penis the catheter is gently advanced. The distal end is elevated and slowly made to describe a semicircle from the abdomen to the space between the legs (Fig. 229). The proximal end will then have entered the bulbous urethra and finally the bladder. Occasionally it will be necessary to guide the tip of the catheter by placing the hand beneath the perineum behind the scrotum. It is needless to say that extreme gentleness is absolutely necessary in all catheterization. When

obstruction is met with, no force should be used, but, rather, further gentle trials at a slightly different angle should be made. (See the sections on treatment of postoperative retention.)

In cases of acute retention of urine caused by *stricture of the urethra* it will be impossible to pass the ordinary catheter. In this case it will be necessary to resort to filiform bougies filled with threaded caps to be attached to a follow-up catheter. The passage of filiform bougies requires considerable skill, patience and gentleness. If the urethra is very sensitive it will be advisable to instill 5 or 10 cc. of local anesthetic solution. For this purpose 0.5 per cent cocaine with 1:1000 epinephrine may be used. More preferable, however, are 1 per cent procaine and 0.5 per cent alypin. The first filiform bougie is passed with traction placed upon the penis until it either enters the bladder or meets with obstruction. In the event of obstruction another filiform bougie is passed in an attenpt to find the minute stenosed opening of the stricture. In case this also meets with obstruction, further bougies are passed until the urethra may contain six or seven, or more. By patient, alternate manipulation of the different bougies, finally one will be made to enter the stricture and will be felt to pass on into the bladder. When this occurs the follow-up catheter will be screwed on the successful bougie, and the other, unused bougies will be withdrawn from the urethra. With the filiform bougie as a guide, the follow-up catheter will now be inserted into the bladder. At the point where the expanding tip of the follow-up catheter dilates the stricture, considerable resistance will be encountered. By steady, gentle and occasionally forceful pressure this resistance will be overcome The tip of the filiform will be coiled up in the bladder when the catheter has finally been passed It is important that the screw connection of the filiform bougie and the follow-up catheter be tight and that the filiform itself be in good condition, or else there is considerable danger that the filiform or parts of it will be left in the bladder after the withdrawal of the catheter

Following such catheterization for *stricture of the urethra* it will be necessary to treat [illegible]

urethrotomy is indicated if instrumentation is followed by excessive bleeding or septic chills. In the event that catheterization has been unsuccessful, *trocar puncture of the bladder* or suprapubic cystotomy will be necessary. If a trocar is used, the bladder is distended, and the skin and the subcutaneous fascia of the suprapubic region are well infiltrated with 0.5 or 1 per cent procaine. A ½ inch incision is made in the midline immediately above the symphysis pubis. The trocar is carefully forced down through this incision into the bladder. *Suprapubic cystotomy* is generally best performed under local anesthesia, but general anesthesia, preferably induced with ethylene, will sometimes be the choice. The Trendelenburg position with the knees spread apart is the best position. A 1½ to 2 inch incision is made in the midline. A longitudinal incision is made through the deep fascia, and the two rectus muscles are spread apart by blunt dissection. Previous to operation the bladder will, if possible, have been distended with sterile fluid or air The finger will now dissect away the fat and areolar tissue above the symphysis and expose the bladder. The latter may readily be recognized by the wavy musculature, the soft fluctuant sensation and the large veins upon its surface. The bladder should not be separated from the symphysis. The bladder is now steadied by two Allis forceps or by two silk traction sutures, and a scalpel is plunged through its wall. For permanent drainage a de Pezzer self-retaining mushroom catheter is placed in the opening. It is held in place in the bladder by the bulbous enlargement. A suture may be placed in the bladder to reduce the size of the opening if necessary. If an ordinary rubber tube is used, the suture may be passed through it to hold it in place. Young advises a suture fastening the tube to the skin. The wound is drained at the lower angle and the wound is approximated.

INFECTIONS

Balanitis.—Balanitis is the term applied to inflammation of the glans penis and is generally found in cases of phimosis, in which it is difficult to retract the prepuce and pathogenic organisms propagate beneath it. *Balanoposthitis* is inflammation of the lining of the preputial cavity, that is, of the prepuce and glans penis. It is a common complication of gonorrhea. A symptomatic

treatment for acute cases will be hot boric fomentations, but the only treatment that offers certain success is circumcision, which is best performed after the inflammation has subsided. The use of zinc peroxide powder, which is blown under the foreskin with an atomizer, has been found helpful by Allison.[27]

Abscess.—Cutaneous abscesses may occur on the shaft of the penis. Abscesses of the body of the penis also may occur as the result of gonorrheal infections. When fluctuation is apparent these are treated by incision and drainage, with particular attention directed toward hemostasis.

Plastic Induration of the Penis (Peyronie's Disease).—In this condition there is fibrous thickening of the corpus cavernosum of unknown etiologic origin, with shooting pains and painful erection. *The Journal of the American Medical Association*[28] says: "The treatment consists of soaking the organ in hot water two or three times a day, followed by mild massage of thickened area. It is desirable in some cases to use the official U. S. P. iodine ointment made with a vanishing cream base instead of the U. S. P. base. Administration of potassium iodide, from 0.65 to 1 Gm. three or four times a day, seems to help in some instances. Application of diathermy to the thickened areas occasionally produces great improvement. Roentgen treatment and radium treatment have been advised. Their value is somewhat doubtful.

"Surgical treatment offers little in the way of cure and is often followed by a prompt recurrence, often in an aggravated form."

Venereal Diseases.—The treatment of venereal disease does not come within the scope of minor surgery, except for such complications as require minor surgical procedures for their treatment. However, mention should be made of the important place in the treatment of gonorrhea which has been taken by the sulfonamides. According to Zide and Davis[29] sulfathiazole is the drug of choice for the treatment of gonorrheal urethritis and its complications. It effected a cure in 95.2 per cent of 145 patients, 88.8 per cent of whom were cured in 21 days or less. Sulfapyridine was less effective, and sulfanilamide was much less successful. Pappas[30] reports cures in early acute gonorrheal infection in from 2.6 to 6.5 days by use of a single dose of 5 to 7 Gm. of sulfathiazole. Four liters of fluids per day was given for several days following chemotherapy. Sulfathiazole is also endorsed by Uhle and his colleagues.[31] Sulfathiazole plus hyperpyrexia as a single combined treatment has given good results in the hands of Ferguson and his associates.[32] Herrell and his colleagues[33] have found penicillin effective in sulfonamide-resistant gonorrheal infections. Oard et al.[34] say that sulfathiazole and penicillin "appear to enhance the effect of each other against gonorrhea." Thompson[35] says: "Penicillin is a particularly valuable drug for the treatment of gonorrhea. The most practical method of administration is the intramuscular injection of a solution containing 5000 or 10,000 units per cubic centimeter. Doses of 20,000 units injected every three hours until 100,000 units has been given will result in cure in fully 98 per cent of the cases."

Stricture of the urethra is most commonly caused by preexisting gonorrheal infection. The treatment of stricture has been described in a preceding paragraph on catheterization. Acute gonorrheal urethritis and cystitis may cause functional retention of urine, the treatment of which has also been described under the subject of catheterization.

Abscess of the prostate gland will occasionally follow gonorrheal infection. The existence of this condition is apparent because of extreme pain in the

region of the perineum, difficulty in urination and defecation, increase in temperature and leukocytosis. Uncommonly, an abscess of the prostate will cause no swelling in the perineum, and the rectal examination, which ordinarily will demonstrate a tender mass, will reveal no abnormality. The diagnosis in these cases will be extremely difficult, if at all possible. The treatment of frank prostatic abscess with a median bulge in the perineum is to place the patient in the lithotomy position and make an oblique incision, starting in the median line and extending backward and outward for a distance of about 4 to 6 cm.; to divide fat and fascia; and to insert a finger to open up the space bounded by the transversus perinei and triangular ligament in front, the central tendon and rectourethralis internally, and the levator ani posteriorly (Young), cautiously deepening the inner portions by blunt dissection until the abscess cavity is entered. A sound is passed into the urethra for guidance in avoiding the urethra. Drainage with gauze or soft rubber tubing will be indicated and hot fomentations instituted to relieve the pain and to accelerate the discharge. Lowsley[36] says: "The method of choice is to do a perineal section, introduce the finger into the prostatic portion of the urethra and then into the abscessed portion of the gland, and clean out the honey-combed interior so that no pockets are left. A tube is then introduced into the bladder, diverting the urinary stream and leading the pus out through the perineal wound. Another method of drainage is to expose the posterior surface of the prostate gland just as one does in doing the Young perineal prostatectomy, and then incise the abscess cavity and insert and fix a tube into it."[37]

Acute epididymitis is a common sequel of gonorrheal infection. (See also Swellings of the Scrotum and Its Contents.) According to Garvin,[38] "Epididymitis is the result of a mechanical transference of gonococci-laden pus from the posterior urethra and seminal vesicles down the vas to the epididymis. It is peritubular extension and not intratubular, involving principally the globus minor and the other portions of the epididymis by periepididymal extension. It is a true epididymitis and not an epididymo-orchitis." Of 3606 cases of epididymitis treated at the Urological Service of Bellevue Hospital, New York, 3000 had resulted from neisserian infection, 280 were tuberculous and 326 were of nonspecific origin. (Campbell[39]) According to Rolnick,[40] "Within a few hours after the bacteria have reached the tail of the epididymis, they penetrate between the epithelium, involve the wall, and extend to the interstitial and peritubular tissues, there to set up the inflammatory process." It is manifested by excruciating pain in the epididymis, swelling, and marked tenderness. The patient will have considerable elevation of temperature and his sufferings will be very marked. The treatment of this condition requires rest in bed; elevation and immobilization of the scrotum by an adhesive suspensory; copious, continuous hot boric fomentations, and catharsis. Penicillin and the sulfonamides, particularly sulfathiazole, should be used. (See section on Venereal Disease.) Stellwagen[41] has described a very useful scrotal support which consists of a wide bridge of adhesive plaster which stretches across the thighs. The bridge has tongue depressors incorporated in it to maintain its breadth. Tapes are fastened to an extension on the lower side of it, and these are tied to tapes which are fastened to the abdomen when the dressings have been put in place. The use of magnesium sulfate solution for hot fomentations has been advocated by some in these cases. Smith[42] recommends

"Fouadin"* is a trivalent compound of antimony and sodium (antimony-III-pyrocatechin-sodium-disulfonate) which was developed in Egypt for the treatment of bilharziasis. Tomskey and his associates[57] cured 102 patients with local application of 20 per cent resin of podophyllum in olive oil. Surgical excision was employed by Robinson and his colleagues[58] in 16 cases. In 13 of these cases, operation was thought to be indicated because chemotherapy had failed. Complete healing occurred in 9 cases, 5 were lost from observation and 5 were unsatisfactory.

Lymphogranuloma Venereum (Lymphogranuloma Inguinale).—Lymphogranuloma venereum is a specific venereal disease due to a filtrable virus which has an incubation period of one to three weeks. Slaughter[59] describes it as an "infectious disease with constitutional manifestations" which is not limited to any "race, age, sex or class of individuals." He calls attention to the lesions in the head and neck. It is essentially a disease of the lymph channels and the inguinal lymph nodes. With lymphogranuloma venereum there may be a primary lesion of the type of a papule, a pustule, an herpetic process, or a specific urethritis, which may be confused with gonorrhea. Following this primary lesion, which is usually evanescent in character, there is involvement of the draining lymph nodes. The adenitis of lymphogranuloma venereum is characteristic. The nodes in a chain become fused together in a large mass, which may reach half the size of the fist, and then the process breaks down, with multiple fistulous openings. Along with the local adenitis there may be systemic symptoms of malaise, loss of appetite, loss of weight, rheumatic symptoms, eruptions on the skin and a temperature elevation which may be of the intermittent, remittent or continuous type. Occasionally the elevation of temperature will persist over a long period, successive flare-ups accompanying the involvement of fresh lymph nodes.

In the female affected with lymphogranuloma venereum the picture may be somewhat different, owing to the fact that most of the lymph channels running from the vulva drain into the nodes around the lower part of the rectum, resulting in an inflammatory reaction of these nodes and secondary involvement of the rectal wall. It has been found that some women, as a result of the local process, later present an inflammatory stricture of the lower rectal walls, which may be annular or tubular in character. Rarely, along with a stricture of the rectum, there may be excrescences around the anal orifice, sometimes accompanied with fistulas, and there may be also more or less elephantiasis of the vulva and fistula formation, known as *esthiomene*.[60]

"One is assisted in making a diagnosis of lymphogranuloma inguinale by the so-called *Frei test*. This is a specific intradermal test performed the same as one makes a tuberculin test. The antigen has been prepared from sterile pus aspirated from the inguinal bubo, from macerated material from diseased glands and from emulsions of the brains of mice intracerebrally infected with the virus, but Sulkin and his associates[61] have found the yolk sac antigen (lygranum) to be the most satisfactory for the Frei test.[62] One-tenth cc. of this material is injected intradermally, and in forty-eight hours there will be a raised erythematous tubercle, from 0.5 to 1 cm. in diameter, in a positive case."[63] Anderson and Harmos,[64] in a study of 54 cases, found the Frei test to be 94.5 per cent specific.

* Imported by Winthrop Chemical Co., New York.

The disease is not uncommonly associated with *rectal stricture;* in fact, Rainey and Cole[65] are of the opinion that the greater portion of benign rectal strictures so commonly observed in Negro women are due to lymphogranuloma venereum. Lichtenstein[66] reports 154 cases of lymphogranuloma venereum in 58 of which there was an inflammatory stricture of the rectum. Sulfanilamide has been thought to have value in the treatment of rectal strictures due to lymphogranuloma inguinale (lymphopathia venerea).[67]

There is no specific treatment for lymphogranuloma inguinale. The sulfonamides (usually sulfanilamide, sulfathiazole or sulfadiazine) are probably the most valuable agents in the treatment, and most patients so treated are either cured or markedly improved. Stein[68] found the results uniformly good with sulfanilamide. He used 60 grains a day for four weeks, 80 grains a day for 3 weeks and 100 grains a day for two weeks. David[69] reported striking improvement in 2 cases of lymphogranuloma inguinale following the use of a sulfonamide. In the treatment of anorectal lymphogranuloma venereum, Grace[70] uses sulfathiazole, "administered in a course which consists of 1.5 Gm. three times daily for two weeks, followed immediately by 1 Gm. three times daily for three weeks." He uses inactivated virus in some cases. The usual treatment is rest in bed and the administration of antimony. "This has been used in the form of antimony and potassium tartrate, a 1 per cent solution being employed and an injection given intravenously of 3 cc. plus 7 cc. of saline solution. The antimony and potassium tartrate is stepped up 1 cc. at a dose, the injections being given once in three or four days until a maximum dose of 10 cc. of the 1 per cent solution is given, and this may be continued for 10 to 15 or more injections, the kidneys being watched for evidence of irritation."[71] Fouadin (see the previous section) should be used perhaps in preference. Weeks *et al.* report good results with excision.

Gangrene of the Scrotum.—In reporting a fatal case of so-called "idiopathic gangrene of the scrotum," Gibson[72] reviews 206 cases collected [illegible] there [illegible] cultur[illegible] are th[illegible] [illegible] he use of anaerobic serum [illegible] ollected reports of 27 cases, [illegible] The mortality is about 28 [illegible] liopathic" gangrene of the [illegible] ent recovered after the use of antiaerobic antitoxin and rather extensive surgical intervention.

TUMORS

Benign Tumors of the Skin.—*Warts* (*verrucae*) and *papillomas* occur chiefly in individuals with phimosis or a long foreskin which is not often retracted for cleansing. Cleanly habits and circumcision are good prophylactic measures against these lesions. These benign neoplasms may be removed by fulguration or by excision. Podophyllin resin, 25 per cent in liquid paraffin, has been recommended by Macgregor.[75] In the case of papillomas excision is somewhat preferable because it permits the histologic examination which is particularly desirable in the case of papilloma and rules out carcinoma. According to Morson[76] any wart on the penis may be the forerunner of papilliferous cancer.

Sebaceous cysts or wens may be single or multiple. They are treated by excision under local anesthesia.

Venous varices and other vascular tumors may occur. Their removal may be more difficult and will generally require a general anesthetic.

Glomus tumor on the penis has been reported in 2 cases by Grauer and Burt.[77]

Lipoma.—Senger and Bottone[78] report a case of lipoma of the scrotum. They say: "The tumor was situated extravaginally, attached to the scrotal wall and had no connection to the spermatic cord. Its probable origin was from fat cells in the loose areolar tissue beneath the dartos. Complete recovery followed simple excision."[79]

Cavernous Hemangioma of the Scrotum.—In reporting a case of this condition, Winslow[80] collected reports of 8 others from the literature. The tumor begins in the first or second decade of life and gradually increases in volume to a size varying between that of a hen's egg and that of two fists. The general health is not affected. The scrotal tumor is confined almost entirely to the subcutaneous tissues and has *no connection with the spermatic* vessels. In all of the cases collected by Winslow a cure was effected by operative means. Complete eradication by excision is the treatment.

Swellings of the Scrotum and Contents.—

Hydrocele. (See section on hydrocele.)

Hematocele (Hematoma).—Hematocele is a collection of blood or sanguineous fluid in the tunica vaginalis. It may be acute or chronic and can be confused with testicular sarcoma. White and Gaines[81] say that the following signs are helpful in the recognition of an acute hematocele:

"History of a local traumatism is significant; transillumination of the scrotum is not possible; testicular sensation is often lost; it is difficult to distinguish the testicle from the epididymis; the swelling is usually round, solid and hard in consistency and about the size of a duck's egg; in weight, the tumor gives the impression of being heavy; the spermatic cord is often thickened; the layers of the tunica vaginalis cannot be felt by palpating between the fingers. Needle puncture for blood in hematocele is useless as a diagnostic measure, and it may be dangerous."

The treatment of acute hematocele is by elevation of the scrotum and the application of heat. Occasionally incision and ligation will be necessary. In chronic hematocele, trauma is absent; the treatment involves excision of the sac.[82]

Traumatic Orchitis.—In cases of trauma to the testes, usually marked shock or fainting, nausea or vomiting and occasionally death are noted. There may be local extravasation of blood. The treatment is usually elevation and external heat.

Mumps Orchitis.—Orchitis occurs in 15 to 30 per cent of young men and boys with mumps but is rare before puberty. It is more often unilateral than bilateral. The testicle is swollen, tender and painful, and the patient has a fever. Wesselhoeft and Vose[83] recommend incision of the tunica albuginea in mumps orchitis. In 9 out of 10 cases there was immediate relief and no atrophy. Otherwise the usual treatment is elevation of the scrotum, external heat and administration of analgesics. Atrophy of the testicle occurs in over 50 per cent of the cases.[84]

Tuberculosis.—Tuberculosis first involves the epididymis and secondarily the testicle. The disease is of long standing, and the epididymis or testicle is nodular and the vas thickened.

Acute Epididymitis. (See section on acute epididymitis.)

Cysts of the Testis and Epididymis.—Cysts of the testis and epididymis are

divided into the serous and seminal varieties. Herzenberg[85] made a study of 26 cases of these cysts and came to the following conclusions:

"Serous and seminal cysts are differentiated by their contents and their location. The former must be considered cysts of the visceral surface of the tunica vaginalis of the epididymis and the tunica subalbuginea of the testis. The latter are situated in the rete testis and the coni vasculosi.

"Subserous cysts occur relatively often (from 12.5 to 20 per cent of cases); cysts in the region of the rete testis and the coni vasculosi (spermatoceles), less frequently (from 2 to 8 per cent of cases); and subalbugineal cysts very rarely (0.05 per cent of cases). Hydatids of Morgagni are found almost always on the surface of the testis and epididymis (from 83.5 to 96 per cent of the cases)."

Spermatocele.—Referring to spermatoceles, Campbell[86] says: "Anatomically, spermatoceles are extravaginal or intravaginal. The extravaginal type, which is the most common, usually arises behind the testicle, between the testicle and epididymis, and develop outside the tunica vaginalis envelope. When they spring from the vasa deferentia or the superior vas aberrans, the rete testis is the site of insertion. They push the testicle downward and forward. They may become lobular because of constricting circular fibrous bands and may attain great size. Cysts developing in the cord from the paradidymis or vas deferens itself are rare and are characteristically pyriform and single.

"The intravaginal spermatocele springs from some part of the epididymis, develops within the tunica vaginalis, and may rupture into [illegible]

[illegible] age. They are rare in old or young adults. Since they cause little inconvenience, their duration varies. The symptoms are chiefly those of a growing mass at the top of the testicle with a dragging sensation in the penis, testicle and cord. Dislocation of the testicle may occur. It may be induced on erection and may be intermittent. It is rare after intercourse. Neoplasia may be suggested, but these cystic tumors grow slowly and are not so hard as carcinoma. Nor should they suggest tuberculous epididymitis. Fluctuation is commonly noted. Transillumination offers little aid in the diagnosis; relatively dense milky fluid is often translucent. In many cases aspiration alone will differentiate spermatocele from hydrocele, hematocele, and chylocele.

"Aspiration of spermatoceles will clinch the diagnosis but will not cure. Excision of the cyst sac is the indicated treatment. This is easily done under local anesthesia. Partial epididy- [illegible]

[illegible] bandage, which prevents oozing and hematocele formation and affords ample support and [illegible] The patient is kept in bed [illegible] The most common com- [illegible]

Prater[88] reports a true cyst of the tunica albuginea

Tumors of the Testicle.—In 96 per cent of cases, testicular neoplasms are malignant.[89]

"More than 95 per cent of testicular tumors originate from aberrant sex cells. New growth may arise from any type of such cell present in the testicle [illegible] three germinal layers (epiblast, mesc [illegible] fore, any type of tumor—connective [illegible] homogenous and heterogenous tumors and, in each, there may be benign and malignant types. They may be found in either normally descended or ectopic testicles." (White and Gaines.[81])

Testicular tumors may be seen at any age, but the average age is 31.7 years. (White and Gaines) They constitute about 2 per cent of all malignant

tumors in the male[90] and occur in 1 of every 993 males admitted to the hospital.[91] The clinical diagnosis is helped by the usual finding of gonadotropic hormone (prolan A) in the urine of patients with embryonal tumors.[92]

The best treatment for malignant tumors of the testicle is early orchidectomy with high section of the cord before the tumor is handled, plus irradiation. Hinman[93] favors radical operation, with the removal of the primary and secondary lymph nodes, in selected cases.[94]

Tumors of the Epididymis, Spermatic Cord and Testicular Tunics.—These tumors are rare. Thompson[95] found records of 26 tumors of the spermatic cord at the Mayo Clinic, of which about 70 per cent were benign, and 13 tumors of the epididymis, of which 40 per cent were benign. Thompson considers tumors of the testicle to be less common and about 60 per cent of them to be benign.

CONGENITAL AND ACQUIRED DEFORMITIES

The Prepuce.—*Phimosis.*—In the condition known as phimosis the distal portion of the prepuce is so narrow and constricted that it is difficult or impossible to retract the foreskin over the glans penis. Many individuals having this condition suffer no discomfort and are able to urinate satisfac-

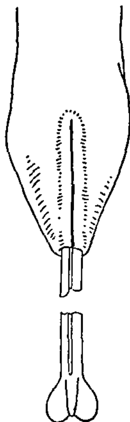


Fig. 230.

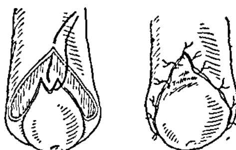


Fig. 231.

Fig. 230.—A grooved director is inserted under the prepuce to the corona; the prepuce is then divided along the director with a pair of pointed scissors

Fig. 231.—Edges of dorsal slit united with interrupted sutures of fine chromic catgut. (From Eisendrath, D. N., and Rolnick, H. C.. Urology, ed 4, Philadelphia, J. B. Lippincott Co.)

torily. In most cases, however, the stream of urine is interfered with, and there is burning irritation of the glans beneath the prepuce because of the continual presence of urine. Williamson[96] reported a case of a phimosed preputial sac serving as an adventitious urinary reservoir. Morson[97] says that phimosis and decomposition of smegma are the main etiologic factors

in ulcerative penile carcinoma. He considers circumcision a most important preventive but not an infallible one. In cases of mild phimosis in young infants divulsion of the narrowed outlet with an artery clamp on one or more occasions will frequently effect a cure. In marked cases circumcision or a dorsal slit will be advised. For inflammatory phimosis, the dorsal slit operation described by Eisendrath and Rolnick[98] is best.

Paraphimosis is a term applied to unreducible retraction of a narrow prepuce. It usually occurs when a contracted foreskin has been forcibly retracted behind the corona glandis and remains there to produce a constriction. According to Schenck,[99] the inflammatory causes are balanitis, gonorrhea, chancre, chancroid, and herpes. Immediate treatment is indicated



Fig. 232.—Method of reposition of paraphimosis. The glans is seized with the thumb and forefinger of the left hand and the penis drawn out. The edema and swelling of the prepuce are massaged by gripping the shaft with the right hand. When the left hand is released, the glans usually will slip beneath the prepuce (After Steinmann from Hinman, F.: Principles and Practice of Urology, Philadelphia, W. B. Saunders Co., 1935.)

to prevent edema, ulceration, and gangrene." The longer the condition exists, the greater will be the swelling, not only of the prepuce but of the constricted glans penis. In early cases efforts should be made to replace the foreskin by gentle pressure applied to all parts of the circumference of the foreskin and exerted distally (Fig. 232). If this steady pressure is maintained for a few minutes, it is occasionally possible to replace the retracted prepuce. Schenck[99] says: "A simple paraphimosis can invariably be reduced without incision, if the following details, as enumerated by Keyes, are observed, viz.:

"1. The stricture must be pulled well back. Exceptionally, the mucous membrane is unfolded at the dorsum; this must be smoothed out by still further retracting the prepuce.

"2. The edema must be thoroughly squeezed from in front of the stricture *to the shaft of the penis behind it.*

"3. Reduction is then accomplished by forcing the stricture slowly over the head of the penis. It is futile to attempt to pry the stricture over the glans until the edema has been reduced.

"A liberal application of vaseline to the glans and prepuce will aid materially in persuading the stricture to slide over the glans."

Pugsley[100] has found the application of a finger cot to the swollen parts to be of value in the reduction of a paraphimosis. In many cases, however, in which the prepuce is too tight or the condition has persisted for too long a time, surgical intervention is necessary. When there is a considerable degree of inflammation it will be advisable to make a dorsal slit (Fig. 233). As a preliminary to this procedure the dorsal surface of the foreskin is infiltrated with 0.5 or 1 per cent novocain solution. A general anesthetic is

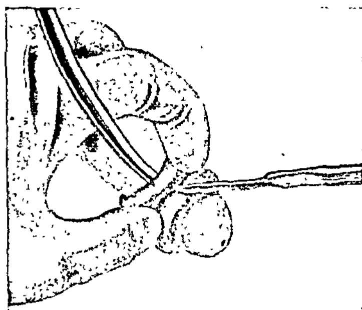


Fig. 233.—Incision of a paraphimosis over a grooved director. (Kurtzahn, H : Kleine Chirurgie, Berlin, Urban & Schwarzenberg, 1929.)

usually preferable. With a sharp knife the upper constricted portion of the retracted foreskin is then cut, and replacement is then possible. In some cases the longitudinal incision may be closed transversely. When this wound has healed and the inflammation has entirely subsided, circumcision generally will be indicated. In those cases in which the degree of inflammation is slight it is occasionally possible to do a circumcision primarily and thus to relieve the condition completely at one sitting.

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stricture will usually suffice. Hemostasis is effected by heat and ligature of the bleeding points with single No. 0 plain gut. This procedure will give good exposure to the lesions, and enable the operator to do darkfield examinations, and to treat the primary lesions and coexisting infection. Incidentally, there will be fewer cases of suppurative inguinal adenitis, and less destruction of tissue. The wound should be dressed with the flaps in their natural position to prevent constriction at their bases. The penis should be elevated. Continuous application of hot Thiersch's solution will be found to be very efficacious in controlling the infection. After the lesions have healed, an acceptable circumcision can be done, under local anesthesia, by amputating the flaps at their bases."

Adherent Prepuce.—In young infants firm adhesions may occur between the prepuce and the glans penis, and although the foreskin is not tight it will be difficult to retract it. These cases are very simply treated by careful cleansing of the foreskin with soap and water and washing with boric solution and then carefully but forcibly retracting the foreskin with the aid of gauze pledgets. This procedure often will have to be supplemented by stripping free the adhesions with the sharp end of a probe. A white sebaceous material will be found beneath the adherent prepuce, and this will be removed as the adhesions are separated. After careful washing the foreskin is replaced. Sterile olive oil may be smeared beneath the prepuce before it is replaced.[101] The mother is told to retract the foreskin daily during the child's bath and after retraction to replace it immediately. The latter advice is important, as was shown by one case in which the mother yielded to the child's protests and left the foreskin retracted, and paraphimosis resulted which necessitated immediate circumcision.

Redundant Prepuce.—The exact definition of redundant prepuce will be difficult. Many individuals with an extreme degree of redundancy have no symptoms whatsoever, and the mere presence of a rather long foreskin is not in itself an indication for circumcision. In some cases, however, where there is redundancy of the foreskin there will be some interference with the urinary stream, and because of the general failure of extreme cleanliness of the under side of the foreskin, mild balanitis or irritation will result. This condition has been thought in some cases to give rise to masturbation in young children. Circumcision will be advised in all cases in which there is irritation beneath the foreskin or interference with the urinary stream. The writer believes that phimosis is also an indication for circumcision. It is considered by some to be valuable prophylaxis against carcinoma. Richter[102] is very conservative with regard to the indications for circumcision and believes that the operation generally is done more frequently than is necessary. The advice to have circumcision performed as a routine treatment of masturbation does not seem logical unless there are definite signs of cutaneous irritation beneath the prepuce. Likewise, the advice to have circumcision done in cases of enuresis seems to have but little logical basis, save as a dramatic psychologic procedure, and on this basis occasionally has been successful.

Preputial Calculi.—Occasionally the sebaceous material included beneath an adherent prepuce will be calcified. Its removal will be similar to the procedures described in freeing adhesions of the prepuce.

Circumcision (Ablation, Posthetomy).—The operation of circumcision has generally been accorded far less respect than the usual difficulties of the procedure deserve. Parents with the idea of doing a favor to struggling young doctors will often intrust to them what they believe to be the most simple operation, little realizing that it requires some judgment and not a

little dexterity for its proper completion. Of recent years it has been the practice of many obstetricians to perform circumcision routinely on all newborn babes. This procedure is not approved by all pediatricians, however. The operation may be done quickly and without anesthesia in the newborn babe and is permanently forgotten by the patient and his parents. How many parents have bewailed the fact that it was not done at birth when the to them, momentous question of circumcision comes up in the child 5 years old.

The first question to be decided in the operation of circumcision is the choice of anesthesia. In infants up to 1 or 2 months old, no anesthetic whatever will be required. From the age of 6 months and up to 13 or 14 years, general anesthesia will be necessary. For a young baby a few drops of ether will suffice to make him hold still and to deaden his pain sensations. In older children the anesthetic makes the procedure a more formal one and in some cases will require hospitalization. Above the age of 13 and 14 circumcision will be performed under local anesthesia, unless the patient himself requests a general anesthesia. The operation is more difficult under local anesthetic because of the distention of the prepuce with the anesthetic solution and the likelihood of inaccurate amputation of the redundant skin. When local anesthesia is elected, a 1 or 2 per cent solution of procaine should be employed. This may be injected by the infiltration method in the operative field or the block method may be used. Of the latter procedure Young and Davis[103] say: "Using a 2 per cent procaine, a circle of injections is made along the base of the penis in the subcutaneous tissues. About 1 cc. of the solution is also injected beneath Buck's fascia on each side."

The cleansing of the prepuce, glans, penis and scrotum should be carefully carried out with mild soap and water. Meticulous soap and water cleansing, particularly with the prepuce retracted, is sufficient preparation. For those who desire an antiseptic solution, mercurochrome acetone solution may be used. According to Scott and Hill,[104] the latter solution is prepared by dissolving 2 Gm. of mercurochrome in 35 cc. of distilled water, to which solution are added 55 cc. of 95 per cent ethyl alcohol and 10 cc. of acetone. The field of operation is then carefully draped with sterile linen. For this purpose a "circumcision towel" is admirable. This consists of a towel in the center of which a small hole has been made, through which the penis may be drawn. If possible it may be desirable to have an assistant help in the circumcision. Many methods have been advocated for the actual operation, but one of the most serviceable methods is as follows:

The lateral margins of the redundant prepuce are grasped with two mosquito forceps and the foreskin put on some slight tension. A dorsal slit is now made either with scissors or with a scalpel upon a grooved director. Extreme care must be taken that the lower blade of the scissors does not enter the urinary meatus, a serious accident which occasionally has happened. If too great tension is applied to the foreskin the dorsal incision will be made too long, and it will be well from time to time to relax the tension on the foreskin and retract it, in order to determine just how far proximally the incision has been made. When this incision has been made of proper length, that is, so that about 0.5 cm. remains above the coronary sulcus, a similar incision is made posteriorly in the median raphe of the foreskin down to the frenum. It is generally inadvisable to cut the frenum. The two lateral flaps

thus made will now be cut across at the base, so that a straight, continuous circle circumscribes the penis at the region of the glans (Fig. 234). A border of the internal flap of the foreskin of ample width to permit suturing must be allowed to remain. This generally should be $\frac{1}{8}$ to $\frac{3}{16}$ inch wide. Some authorities believe that at the completion of the operation enough foreskin should remain to cover the corona. Young says that "the advantage of this conservative operation is that the normal sensitiveness and lubricating secre-

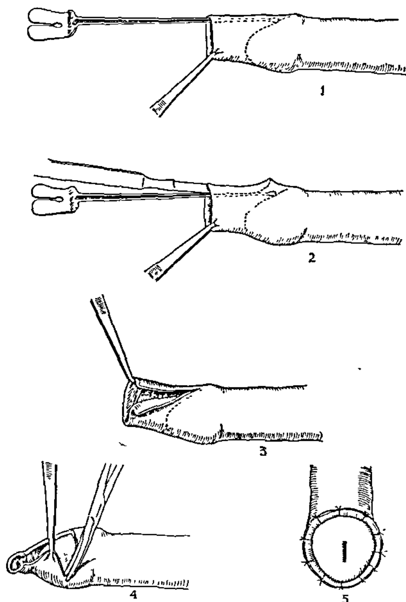


Fig. 234.—A method of circumcision. (Pugh, W. S.: S. Clin. North America 15: 461, 1935.)

tions of the preputial skin are retained, both of which are said to be much appreciated in later life." This, however, seems unnecessary. It is particularly important at this point to secure complete and accurate hemostasis. The artery of the frenum should be clamped and tied with very fine silk, and one should not rely on the sutures which approximate the wound to effect hemostasis. The skin edges should be approximated by means of very fine interrupted sutures. As many as 10 to 16 may be necessary. The a

fine non-absorbable sutures on a fused needle. (Dermalon is satisfactory.) Very fine catgut may be used. The more accurately the skin edges are approximated, the more rapid will be the healing. Inversion of the skin edges is to be avoided. Bettman[105] suggests a simple technic employing towel clips. Hersh[106] recommends subcuticular mattress sutures. An ingenious clamp for circumcision has been described by Yellen.[107] (Fig. 235.)*

The author prefers to apply no dressing at all for a child but to place him in bed with a cradle to keep off the bed covers. The nurse is instructed to *sponge the wound with tepid saline or boric acid solution* every 15 to 30 minutes for a few hours and occasionally thereafter. In a few hours a dry wound which is almost painless will result.

In adults, gauze bandage or curtains will be employed. The writer does not favor the procedure of tying a small strip of gauze over the wound by means of the long ends of the sutures. The parents or attendants are instructed to change the bandage after each urination or defecation and carefully to *irrigate the parts with warm boric acid solution.* Vaselin gauze dressing is undesirable but, if used, should be discontinued as soon as possible, preferably after a few hours, and the wound encouraged to dry and form scabs. When there is practically no bleeding the vaselin dressing may be dispensed



Fig. 235.—Circumcision clamp. (Yellen, H.: Am. J. Obst. & Gynec. 30: 146, 1935.)

with and a dry dressing put on at the operation. A very satisfactory type of dry dressing is obtained by making a curtain of sterile gauze which is suspended from the abdomen by adhesive plaster and hangs down over the wound. The dressing described by Clarke[108] is comfortable and satisfactory. It is made from a gauze pad measuring 9 by 30 inches and containing thirty-six thicknesses. (Fig. 236.) In adults the employment of sodium bromide may help prevent erection. Pugh[109] has written an interesting paper with an account of the accidents following circumcision. Most of these are due to careless hemostasis. Many pediatricians have found that after circumcision, irritation from diapers causes ulcers of the meatus. When these ulcers heal, stenosis takes place which often requires meatotomy so that the stream is adequate. (See Meatotomy.) Fraser[110] says that useful measures to prevent meatal ulcers are keeping the meatus as dry as possible and applying a small quantity of adrenalin and cocaine ointment or zinc ointment.

Urethra.—*Narrow Meatus.*—The urinary meatus occasionally may be so narrow as to interfere with the diameter of the urinary stream and cause some difficulty in urination. *Treatment consists* either of gradual dilation

*The circumcision clamp is made by the Gomco Surgical Manufacturing Corp., 71 Ellicott St., Buffalo 3, N. Y.

with sounds of increasing size or of *meatotomy*. The latter operation is performed under local anesthesia and consists in enlarging the meatus by a longitudinal incision at the posterior margin. The hemorrhage generally will be slight and is usually controlled by pressure, although occasionally ligature is necessary.

According to Schenck,[99] if adrenalin has been employed, the bleeding is usually slight, but gentle lateral compression should be applied by the operator until it subsides. Schenck also says that "it is important to remember that the internal meatus at the depth of 1 cm. is often tighter than the meatus itself. A No. 28 F. bougie is introduced immediately. If it will not pass readily, or if it catches on the restriction as it is withdrawn, further cutting is required."

Ballenger, Elder and McDonald[111] have performed 119 meatotomies with very satisfactory results by the following method: "Preliminary to the injections of novocain about ½ ounce of a 1 or 2 per cent solution of novocain is injected into the urethra and held for



Fig. 236.—Details of circumcision dressing and the dressing in place. (Clarke, B. G.: Am. J. Surg. 64: 129, 1944.)

two or three minutes. This partially anesthetizes the mucous membrane so that the needle puncture can be made just on the inside of the meatus through the mucous membrane with less pain than through the skin. One or 2 drops of adrenalin solution are added to the novocain to lessen the bleeding at the time of the operation and thus facilitate suture. After the incision is made, the first sutures are placed at the outer edges of the cut, catching only the skin and mucous membrane in the sutures. Reaching the deeper part of the mucous membrane is made easier by temporarily leaving the second and third stitches long and using them as retractors to open up the meatus and expose the inner margin of the mucous membrane." In their experience, meatotomy performed in this way is definitely superior to the other methods. "The operation requires five or ten minutes longer, but the final results more than justify this slightly longer time. Occasionally the shape of the glans penis and meatus make it desirable to cut the upper, not the lower, part of the meatus."

Hypospadias, which is the congenital opening of the urethra on the under side of the penis; *epispadias*, which is the congenital opening of the urethra on the dorsum of the penis, and *exstrophy of the bladder*, which is that congenital malformation in which there is deficiency of the abdominal wall and bladder, so that the latter organ appears to be turned inside out, are all conditions requiring complicated major surgical procedures.

A *urinary fistula* may occur as a result of a wound of the urethra or of an abscess of the penis and perineum which may cause the formation of a communication into the urethra. Most of these urinary fistulas will close spontaneously in time, but in cases in which six months' to a year's trial has been made, it will be advisable to attempt the operative closure. This may be done under local anesthesia with a sound in the urethra. The fistulous tract is dissected down until the urethra is reached, and the latter is closed with fine stitches of plain catgut. The external wound will be closed except for a small silkworm gut or rubber drain.

Stricture of the Urethra. (See Acute Retention of Urine.)—Rusche[112] makes the following important statements in regard to stricture of the urethra:

"True stricture of the urethra is a cicatrix of the urethral wall left there by some injury or inflammation, and manifesting a constant tendency to contract, and thus to diminish the lumen of the urethra. This tendency to contraction, which is always manifested in a greater or less degree, is doubtless caused by the irritation incident to micturition; the impact of the stream against the barrier, for the deepest stricture, the one which most obstructs the flow of urine, is almost always the tightest and if the stricture is kept dilated so as to afford little or no obstruction, the tendency to recontraction is slight.

"Stricture occurs in the female as well as in the male urethra. But this lesion in the female is much less common, and manifests no distinguishing peculiarities.

"Several classifications of strictures have been offered, but one I like best is to class them as inflammatory, traumatic and inflammatory strictures which have been operated and thereby have had true scar tissue added to them. About 90 per cent of all strictures of the urethra are due to inflammatory causes; 10 per cent are of traumatic origin. Inflammatory strictures are usually multiple, the deepest being always the narrowest. Sixty per cent of all gonorrheal strictures occur in the deep urethra. We find that 64 per cent of all strictures of the male urethra occur in this portion of the canal.

"Dilatation is the accepted method of treatment of urethral stricture today. But indulged in carelessly it has fallen into disuse since it only adds to our trouble. Torn tissues always heal by the addition of scar. Dilatation can be performed in two ways, either by temporary or continuous pressure. The temporary method, that is, the passage of a bougie or sound which is allowed to remain for a few seconds to a few minutes, is applicable to a stricture of large caliber. The continuous method, where the bougie is allowed to remain for a number of hours or days, is suited to use in very narrow strictures of the deep urethra."

Testicle.—*Undescended testicle* (*cryptorchism*) is of fairly common occurrence (about 1 in 1000), and the degree of the failure of descent is variable. The testicle may rest in the upper part of the scrotum, in the inguinal canal or in the abdominal cavity. The cause is probably an abnormality in the gubernaculum testis.[113] In making the diagnosis one should be careful to distinguish between the patient with a true undescended testis and one who has a very strong cremasteric reflex. Sarcomatous degeneration is rare in cryptorchism but, according to Fraser, is more likely to occur in the inguinal than in the abdominal testis. Pace and Cabot[114] made a study of 24 cases of retained testes in adults and concluded that the abnormally placed testis is

much more likely to become the site of cancer than is the normally placed one. Hinman and Benteen[115] state that "among approximately 40,000 hospital male patients, tumor of the testis occurred 20 times as frequently in undescended testes as in those normally placed." Malignant growth is more frequent in cases of abdominal nondescent than in inguinal nondescent.[116] Rea[117] says: "The undescended testis, either untreated or after orchiopexy, never attains the full functional capacity of the normally descended organ as far as the production of spermatozoa is concerned. However, the value of orchiopexy in promoting the development of the undescended testis has been proved clinically and experimentally in both natural and experimentally produced cryptorchids." Johnson[118] says: "In 313 of 544 cases of cryptorchidism spontaneous descent occurred; operation was performed in 14 instances. No follow-up examinations were made after discovery of the condition in 63 instances, and 154 patients were lost. Undescended testis as a manifestation of Fröhlich's syndrome is not of frequent occurrence and as a companion to other congenital defects is rare. In the 14 cases of orchidopexy here discussed, the results, evaluated according to a new system, were extremely discouraging."

Cabot and Nesbit[119] say that orchidopexy probably had best be performed before the age of 9 years. Turner[120] says that 9 years is the age at which to begin hormone treatment. If this treatment fails after a 12 month trial, operation should be carried out. Under certain circumstances, surgical treatment may be delayed to as late as 14 years. Smith[121] says: "Although operation should be postponed until puberty, delay after that is fatal to the testicle." Rieser[122] says that the sixteenth year is the time to operate. The operative treatment of undescended testicle is a major procedure. In adults an undescended testicle, situated opposite the pubic ramus, is always treated surgically because of the danger of traumatism.

The author confesses that he is considerably impressed by the following remarks of Drake:[123]

> "What, if any problem is presented by the undescended testicle? Cosmetic considerations may be summarily dismissed. Psychic effect from failure of a testis to descend scarcely merits serious consideration. It is established that even bilateral nondescent of the testis has no deleterious effect on the physical or mental development. Functionally, one normal testis is as efficient as two. A malignant condition occurs more often in an undescended than in a descended testis but at that is of rare occurrence. In contradiction to Bland Sutton's statement that a testis fails to descend because it is abnormal, Wangensteen states that the undescended testis before puberty is indistinguishable macroscopically and microscopically from the normal. The [illegible]
> present any surgical pr[illegible]
> The great majority desc[illegible]
> and fourteenth years), b[illegible]
> only case that should be [illegible]
> fourteenth year or the [illegible] presenting complications."

The original enthusiasm for the employment of gonadotropic substance in the treatment of an undescended testicle has diminished. The uncertainty as to the proper dosage, and its stimulation of genital growth and testicular function should lead to conservatism in its employment. Rea[124] describes the results as disappointing. Rieser[122] considers glandular therapy before puberty questionable and at puberty unnecessary. In a discussion of the status of glandular therapy for an undescended testis, Thompson and Heckel[125] say:

"The effect of the anterior pituitary-like principle from the urine of pregnant women in the treatment of undescended testes appears to be exaggerated. With thirty-eight patients [illegible] only the twenty-eight patients under 61 years of age are considered, descent was produced in nine of thirty-three undescended testes, or in 27 per cent. Descent did not occur in any instance in which the testis was intra-abdominal or deflected over the external oblique muscle.

"It follows that in the majority of cases of true undescended testes, operative procedures are still necessary because of mechanical factors which prevent descent.

"The administration of the anterior pituitary-like principle makes it possible at an early age to distinguish between those testes which require surgical intervention and those which do not. When the testis does not come down, the treatment may facilitate subsequent operative procedures by enlarging the parts involved.

"The value of this form of treatment depends on the importance of getting the testis into the scrotum as early as possible. If early descent is important, the management of cases of undescended testes involves the intelligent combination of medical and surgical measures.

"Treatment should be discontinued before genital growth becomes excessive.

"In evaluating the effect of treatment it is important to exclude all cases of pseudocryptorchidism.

"Many unsolved problems, such as the influence of premature stimulation of the testis on its function later in life, on skeletal growth and on social adjustment, make it necessary to preserve an open mind on the treatment of undescended testes with the anterior pituitary-like principle from the urine of pregnant women.

"It is possible that this material causes descent only of those testes which would descend without treatment about the time of puberty."

The last paragraph of the foregoing quotation may be particularly significant. Mimpriss[126] says that gonadotropic hormones should never be used in cases of unilateral maldescent of the testis. He believes they should be used only when both testes are undescended and there is subnormal genital development. Smith[121] recommends a postoperative course of hormone therapy.[127]

Misplaced or Ectopic Testicle.—The testicle may be congenitally misplaced or aberrant. According to Campbell,[128] the varieties of ectopic testicle are "(*a*) interstitial (lying anterior to the aponeurosis of the external oblique muscle), (*b*) femoral or crural (lying in Scarpa's triangle), (*c*) penile (overlying the pubic bone), (*d*) perineal and (*e*) transverse. In the last instance the two testes descend through the same inguinal canal." The treatment of this condition is a major surgical problem.

The Tunica Vaginalis and Cord.—*Hydrocele of the Tunica Vaginalis.*—An excessive amount of clear fluid in the tunica vaginalis is described as hydrocele. After the fluid content of the scrotum has been made certain by the demonstration of fluctuation, the existence of a hydrocele will be established by transillumination. This is preferably done in a darkened room by holding a pocket flash-light behind the scrotum. The cavity formed by the hydrocele may or may not communicate with the abdominal cavity. Hydrocele in infants generally disappears spontaneously.[129] In young children the disappearance of the hydrocele upon compression will be proof of its communication with the abdominal cavity, and a diagnosis of potential hernia may be made. Such a condition may require a major surgical operation for cure.

The hydrocele may be treated by the "bottle operation" (Andrews), by excision and eversion of the redundant tunica vaginalis (Winklemann), or by the operation described by Hugh Young. In the Andrews "bottle operation" the testicle is extruded through a small incision in the tunica vaginalis. The sac is thus turned inside out, and the opening may or may not be narrowed

by suture to prevent the testicle from returning to the tunica vaginalis. The testicle and sac are then returned to the scrotum. This operation is very readily accomplished under local anesthesia. In the excision and eversion operation of Winklemann the parietal layer of the tunica vaginalis is trimmed away to about ½ inch from its visceral insertion on all sides, and these flaps are sutured together behind the epididymis. In the Young[130] operation the skin, subcutaneous tissues and dartos of the scrotum are cut through, and the hydrocele sac is delivered. The seven layers of the hydrocele are stripped back in groups of the first five and the last two until the thin tunica vaginalis remains. The sac is then opened and the thin serosa of the tunica vaginalis excised. The testicle is replaced in the scrotum, a small drain inserted, the wound closed and a compression elevating dressing applied. The operation of Wolf[131] is simple and has proved successful in his hands. Particular care should be taken of hemostasis. Hemorrhage is the most serious complication (Young), and the recurrences after radical operation are said to be only 5 per cent. Aspiration of the hydrocele may sometimes be employed as a palliative. It occasionally effects a cure in children. A small area of the skin and underlying tissues may be infiltrated with 1 per cent procaine. The scrotum is so grasped that the testicle is well out of the way. The trocar or aspirating needle is introduced into the scrotum with caution in order that it does not penetrate too deeply and thus injure the testicle.

Since the introduction of the newer sclerosing agents, the *injection treatment of hydrocele*, which had fallen into disrepute, has been revived. Riba[132] reported a case of infectious gangrene of the scrotum following the injection treatment of hydrocele. Baretz,[133] one of its advocates, goes so far as to say: "Operation for hydrocele should eventually be entirely supplanted by this procedure because of (1) its simplicity; (2) the absence of pain and harmful effects or invalidism; (3) the apparently permanent cure; (4) the avoidance of hospitalization and its concomitant economic loss; (5) the elimination of surgery and its associated danger."

The solution recommended by Greene[134] and by Baretz is quinine hydrochloride 13.33 per cent and urethane 6.66 per cent. Solley[135] prefers 5 per cent solution of sodium morrhuate in benzyl alcohol. The scrotum is shaved, carefully cleansed with soap and water and dried. The skin is then painted with mercresin or mercurochrome-acetone solution, and the parts are carefully draped with sterile towels. It is best for the surgeon to wear sterile gloves. A local anesthetic may be used in the skin. The technic is described by Greene as follows:

"The injection [illegible]
17 [illegible]
con [illegible]
pal [illegible] contents is done for detection of pathological changes in the testicle and epididymis. Two to 4 cc. of the quinine and urethane solutions are injected, the needle withdrawn and by manipulation an effort is made to distribute the solutions throughout the sac. A snug bandage or suspensory is applied and the patient allowed to go his way. Fluid nearly always reaccumulates within one week after the first injection. The procedure is repeated at that time using quinine dihydrochloride, 3 to 10 cc. Should fluid again form, an interval of three weeks is allowed before repeating subsequent injections. The fluid aspirated after the first injection is hazy and contains fibrin. Some cases require only one injection, but the average case requires two to three, and occasionally an even greater number is necessary. Should epididymo-orchitis develop, as it occasionally does, during the course of the treatment, it must be allowed to subside before continuing.

"Injection treatment may be employed with safety and with assurance of good result in simple chronic sterile hydrocele. It is not indicated in the congenital variety or where there is serious pathology present in the testicle or epididymis. It is not suitable where haste is a necessity. Sacs of 1200 cc. capacity have been treated successfully by injection. The procedure is simple and may be readily carried out as an office procedure. Few require sedatives or confinement to bed.

"There have been, as yet, no large series of cases reported. There are, however, many small series and the results compare favorably with the reports of the operated cases.

"An assistant is desirable and almost a necessity in tapping and injecting a hydrocele. I find very frequently that it is impossible to drain the sac completely even with assistance. This fact is believed to be responsible for some of the failures when injection is done. I do not believe that injection treatment should be substituted for radical operation under usual circumstances.

"In a certain number of patients tapping alone seems to be the desirable form of treatment for one reason or another. It does not effect a cure. We have a number of patie[illegible] m we have tapped, at intervals of from three to nine months, over [illegible] d there has never been a complication following [illegible]

Robertson[136] describes his tech[illegible]

"The scrot[illegible]

Two areas in [illegible] large blood vessels are sel[illegible] A No. 18 to 20 gauge needle is inserted thr[illegible] pushed for one-half inch through the subcutaneous tissue [illegible] into the hydrocele sac. This method of inserting the needle prevents leakage of the sclerosing solution through the scrotal wall. A smaller needle is inserted into the other anesthetized area in the same manner. This aids in the aspiration of the fluid as it destroys the negative pressure. The fluid is withdrawn, and sufficient 2 per cent novocain solution is injected through the large needle to distend slightly the sac and to surround the testicle completely. The novocain reduces the pain from the sclerosing solution. It is permitted to remain in the cavity for ten minutes. Following its aspiration, 3 cc. of 5 per cent sodium morrhuate with benzol alcohol is injected into the hydrocele sac. The needles are withdrawn and the scrotum massaged to secure an even distribution of the solution through the cavity. A modified Bellevue adhesive suspensory is applied and the patient ordered to remain in bed for two days."[137]

Baretz followed 42 of 59 patients after injection treatment and found perfect results in 70 per cent. Porritt[138] has reported 20 cases of hydrocele treated by injection with only one complete failure. Ewell and his associates[139] cured 95.7 per cent of 165 patients with the injection treatment.

Hydrocele of the Cord.—By hydrocele of the cord is meant a small, circumscribed collection of fluid which arises from the cystic enlargement of a portion of the funicular process. It may readily be removed under local anesthesia. If there is coincident congenital hernia, this defect should receive proper radical treatment.

Varicocele.—In *varicocele* the veins of the spermatic cord are abnormally enlarged, and the scrotum may look and feel somewhat like a bag of worms. Warwick[140] believes that varicocele depends primarily on incompetence at the orifice of the spermatic vein and, further, that the condition is produced by refluxes from the vena cava along the spermatic vein. This condition has for many years been the excuse for much mistreatment on the part of genito-urinary quacks. The patient is solemnly told that the condition is a very serious one and that an operative procedure is probably the only method of saving his life. The large majority of varicoceles will require no treatment whatsoever, as the condition is without danger or significance. In cases in which the venous enlargement is so great as to cause an uncomfortable sensation of weight or pain in the testicle or groin, an operation will afford relief. Riba[141] says: "Aside from persistent pain and discomfort, evidence of

testicular atrophy resulting from poor circulation is an indication for operative interference."

Achenbach[142] says: "Resection of the plexus is associated with a number of dangers. When the surgeon has been too radical, the flow of venous blood from the testicle may not be sufficient. As the result of knotting of the venous stumps with one another, the resected veins may become patent again. The internal spermatic artery, which is difficult to recognize and isolate, may be ligated accidentally. Moreover, it is usually impossible to avoid resection of the fine nerves leading to the testicle, which frequently results in subsequent atrophy of the organ." Riba[141] warns that troublesome complications may follow the operation for varicocele: "If surgery interferes further with the blood supply, atrophy of the testicle will naturally ensue. Also, possibly due to disturbed postoperative circulation, a hydrocele may develop. For this reason, as a prophylaxis, a few surgeons recommend resecting a portion of the tunica vaginalis at the time of operation. Owing to these unavoidable complications and sequelae, surgeons of experience become more cautious in recommending or performing the usual varicocelectomy."[143]

The commonest type of operation is to make a longitudinal incision into the scrotum under local anesthesia and from the bulk of the cord structures to isolate the vas together with the artery of the vas and one or two small veins. The remaining enlarged veins are then ligated with transfixion sutures at or near the inguinal ring and below near the testicle. The intermediate portion, some 2 to 5 inches, is then excised, and the ligated ends may or may not be sutured together.

Campbell[144] has made a very interesting study of varicocele based upon 500 cases. This writer says that the suspension operation devised by Vincent, of the Urological Service at Bellevue Hospital, is the procedure of choice because it uniformly relieves the pain and the drag on the testicle, and the postoperative sequelae are minimal. Campbell describes this operation as follows: "After novocaine infiltration, a low hernia incision exposes the external ring and the emerging spermatic cord. Further cord infiltration is usually advisable at this point (Fig. 237) The vessels are exposed by a longitudinal incision through the cremaster and the funicular sheath. The anterior vessels are separated from the deferential group as high as the external ring and down to a point, which, when raised to the level of the external ring, will elevate the testicle about 2 cm. higher than it normally hangs. These mobilized anterior veins—constituting the main body of the varicocele—are divided between clamps (Fig. 237, B) and each is tied securely with a transfixion ligature at least 1 cm. from [illegible]

[illegible] upper portion of the elevated venous stump becomes partially fibrosed to its new inguinal position. Unless this support is applied, there is likely to be slipping of the suspended organ even though chronic suspension sutures are employed. This method was followed 398 times in this series. In the remainder, the generally used end-to-end tying of stump ligatures after venous excision was performed. Five days in bed, postoperatively, usually suffices; the average period of hospitalization in uncomplicated cases was 6 4 days.

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"The scrotum should be shaved and scrubbed with soap and water preceding the injection Two areas in the scrotum wall that transilluminate and are relatively free of large blood vessels are selected. These areas are infiltrated with novocain. A No. 18 to 20 gauge needle is inserted through the anesthetized skin and pushed for one-half inch through the subcutaneous tissue and then plunged into the hydrocele sac. This method of inserting the needle prevents leakage of the sclerosing solution through the scrotal wall. A smaller needle is inserted into the other anesthetized area in the same manner. This aids in the aspiration of the fluid as it destroys the negative pressure The fluid is withdrawn, and sufficient 2 per cent novocain solution is injected through the large needle to distend slightly the sac and to surround the testicle completely. The novocain reduces the pain from the sclerosing solution. It is permitted to remain in the cavity for ten minutes. Following its aspiration, 3 cc. of 5 per cent sodium morrhuate with benzol alcohol is injected into the hydrocele sac. The needles are withdrawn and the scrotum massaged to secure an even distribution of the solution through the cavity. A modified Bellevue adhesive suspensory is applied and the patient ordered to remain in bed for two days."[137]

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[illegible] on a blunt or aneurysm needle, are introduced into the inguinal canal under guidance of the director or knife handle and at a point opposite the internal ring are separately pushed through the aponeurosis of the external oblique. They are then tied over the few intervening strands of aponeurosis (Fig. 237, C). The tying of this ligature pulls the distal stump [illegible]
than its usual level and [illegible]
We then apply the Bel[illegible]
and suspension until [illegible] portion of the elevated venous stump becomes partially fibrosed to its new inguinal position. Unless this support is applied, there is likely to be slipping of the suspended organ even though chromic suspension sutures are employed. This method was followed 398 *times in this* series. In the remainder, the generally used end-to-end tying of stump ligatures after venous excision was performed. Five days in bed, postoperatively, usually suffices; the average period of hospitalization in uncomplicated cases was 6.4 days.

"We are careful, in performing varicocelectomy, to keep away from the tunica vaginalis unless it is to be opened for hydrocele, as trauma will increase the probability of subsequent hydrocele. In elevating the testicle, if one carelessly pulls too hard, the tunica vaginalis will not infrequently be found presenting in the wound, an excellent position for traumatization."

In 1934 Londres[145] described a fascial suspension operation for varicocele. The testicle is suspended by means of a flap (½ inch wide and 2 inches long) cut from the fascia of the external oblique muscle which is folded downward so that its pubic insertion remains attached and its loose end is fixed with silk to the testicle just below the pubic bone. The opening made in the external oblique fascia is sutured. Skinner[146] says: "During the past six years we have operated upon 44 cases in this manner with very good results and without any ill effects Over half of these cases have been observed for a period of a year or longer,

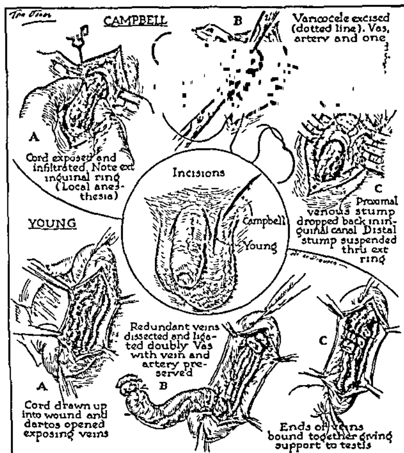


Fig. 237.—Operative treatment of varicocele. The technic of Campbell (Campbell, M. F.: Surg., Gynec. & Obst. 47: 558, 1928) is shown in the upper half of the illustration and that of Young in the lower half. (By permission of Johnson & Johnson.)

and it was found that they were completely relieved of symptoms, did not have any hydrocele, and the fascia support was holding the testicle in the proper position . . . In addition to the suspension, we have been removing a section of the anterior pampiniform plexus, if markedly varicosed, due care being given not to injure the spermatic artery and not to interfere with the middle or posterior position of the cord." He would rather err by not removing enough veins than by removing too many.

OPERATIONS ON THE VAS DEFERENS

all parts of the seminal vesicles. In this operation the vas is picked up in the upper part of

the scrotum with the thumb and forefinger. It may be identified by its hard, cordlike consistency. Without release of the tissues thus held, a few drops of local anesthetic is injected into the skin, a small incision made and the cord drawn into the wound. The vas is isolated and put on a tension by means of a tape or instrument, and a hypodermic needle is introduced into the lumen (Young). The patency of the vas may be tested by injection of methylene blue, which should emerge from a catheter in the prostatic urethra (Young).

Resection of the vas (vasoresection) has received attention in recent years as a method of sterilizing the male without, it is said, causing loss of sexual power or any interference with systemically beneficial secretions of the testicle. It has been advocated in the case of the hopelessly insane and in the case of criminals as a preventive of propagation.

Debatable is the propriety of the employment of this measure in the case of married couples who for legitimate reasons desire no more children. Enlightened opinion will probably favor its increasing use. In cases of large families where a limited income prevents the proper rearing of additional children or in cases in which the health of the wife contraindicates further pregnancies, this measure would seem far less dangerous, less formidable and more available than resection of the fallopian tubes in the female. It will, of course, require a certain amount of sacrifice on the part of the husband, in that he may be permanently deprived of his powers of procreation. In this connection, however, it is to be said that reconstruction of a resected vas is mechanically possible, although extremely difficult to accomplish successfully.

Resection of the vas may readily be carried out under local anesthesia. The vas is picked up between the thumb and forefinger, and the overlying skin is infiltrated with a local anesthetic. A longitudinal incision is made over the vas, which is then identified by blunt incision. A $\frac{1}{8}$- to $\frac{1}{2}$-inch section of the vas is then excised, and the open ends of the remainder are ligated. In some cases it will be advisable to overlap these ends and stitch them in place. The mere excision of a portion of the vas, however, is sufficient to secure sterilization.

Dickinson[147] reports a very [illegible] and feebleminded men in Cali [illegible] the United States Supreme Court." [illegible] C...ornia is described by Dickinson as follows:

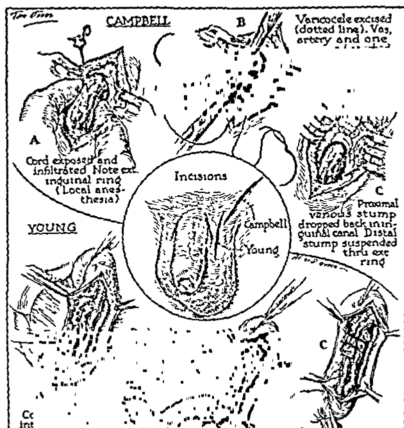
"For closure of the vas deferens, the method used in California is ligation low down, with removal of a small section. Because they are dealing with the insane and feebleminded, general anesthesia is employed somewhat more frequently than local anesthesia. The preparation is as elaborate as for a laparotomy. The incisions are made on the anterior surface of the scrotum, though the vas lies at the back of the cord. The opening is just above the epididymis, and about ½ inch in length (varying from ¼ to a full inch). While this incision is long enough to [illegible] vas, the skin contracts [illegible] ıoted that the large vein [illegible] ...cately stripped, and that precautions were taken against postoperative oozing from the tissues separated from the vas, such as its accompanying and attached artery and the group of veins. At Stockton, Patton and Agnew, the tissues, presumably the cremaster fascia and common vaginal tunic and some cremaster fibers, were sutured with catgut to interpose a layer between the cut ends, but it was evidently nowhere thought necessary to suspend the testicle by suturing the low recut end to the wound as is done by Orth and Schmidt, except that at Stockton this end was included in its tunic suture.

"We are careful in performing varicocelectomy to keep away from the [illegible]

[illegible]

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[illegible]

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OPERATIONS ON THE VAS DEFERENS

Vasostomy.—In cases of infection of the seminal vesicles Belfield and others have recom- [illegible] measure. [illegible]

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Resection of the vas (vasoresection) has received attention in recent years as a method of sterilizing the male without, it is said, causing loss of sexual power or any interference with systemically beneficial secretions of the testicle. It has been advocated in the case of the hopelessly insane and in the case of criminals as a preventive of propagation.

Debatable is the propriety of the employment of this measure in the case of married couples who for legitimate reasons desire no more children. Enlightened opinion will probably favor its increasing use. In cases of large families where a limited income prevents the proper rearing of additional children or in cases in which the health of the wife contraindicates further pregnancies, this measure would seem far less dangerous, less formidable and more available than resection of the fallopian tubes in the female. It will, of course, require a certain amount of sacrifice on the part of the husband, in that he may be permanently deprived of his powers of procreation. In this connection, however, it is to be said that reconstruction of a resected vas is mechanically possible, although extremely difficult to accomplish successfully.

Resection of the vas may readily be carried out under local anesthesia. The vas is picked up between the thumb and forefinger, and the overlying skin is infiltrated with a local anesthetic. A longitudinal incision is made over the vas, which is then identified by blunt incision. A $\frac{1}{8}$- to $\frac{1}{2}$-inch section of the vas is then excised, and the open ends of the remainder are ligated. In some cases it will be advisable to overlap these ends and stitch them in place. The mere excision of a portion of the vas, however, is sufficient to secure sterilization.

Dickinson[147] reports a very [illegible]
and feebleminded men in Cali[illegible]
done than in all the rest of the [illegible]
in some 633 cases reported in [illegible]
to sterilize citizens for its own good has been settled by the United States Supreme Court." The technic of the operation as carried out in California is described by Dickinson as follows:

"For closure of the vas deferens, the method used in California is ligation low down [illegible]

[illegible] though the vas lies at the back of the cord. The opening is just above the epididymis, and about $\frac{1}{2}$ inch in length (varying from $\frac{1}{4}$ to a full inch). While this incision is long enough to [illegible] vas, the skin contracts [illegible] noted that the large vein [illegible] was [illegible]ately stripped, and that precautions were taken against postoperative oozing from the tissues separated from the vas, such as its accompanying and attached artery and the group of veins. At Stockton, Patton and Agnew, the tissues, presumably the cremaster fascia and common vaginal tunic and some cremaster fibers, were sutured with catgut to interpose a layer between the cut ends, but it was evidently nowhere thought necessary to suspend the testicle by suturing the low recut end to the wound as is done by Orth and Schmidt, except that at Stockton this end was included in its tunic suture.

"Ligation was done at both ends or else at the upper end alone, and the two procedures were found with about equal frequency. Plain or chromic gut was used, with fine silk at Stockton only.

"*Steps of Operation.*—The testicle is drawn downward; the whole spermatic cord is lifted in a line between the thumb and index finger of each hand; and the vas is rolled up just beneath the sk
cord seem to b
tenaculum or c
is held tense.
skin-covered loop is lifted, and the incision through the skin, from ½ to 1 inch, is handily made. At Patton, instead of sharp points, the seizure is made with rubber-shielded tips on the forceps. Either thumb forceps or clamps seize the vas and pull out a loop of an inch or more. The tissues are stripped back about an inch with particular attention to the fine artery and the veins lying close to the cord. Sometimes, after clamps are placed, the vas is cut and the clearance of the loosely attached tissues behind it is then made. A clamp has the advantage over the grasp by tissue forceps in that the duct cannot slip out of sight. After the dissecting or pushing back of the loose tissue, ½ inch or less of vas is cut away. Oozing is searched for and a fine catgut suture ligature on a round needle is used in case of doubt. If tissues are to be interposed between the ends, a buried fine catgut continuous suture whips over three or four bites, and the upper end is ligated with catgut in the groove crushed by the seizure of the upper clamp.

"The wound is often collodion sealed, and then straps, bandage or suspensory hold the scrotum quiet. One or two days in bed is the average, with two or three days in the surgical ward."

these men to bring in condom specimens for the first two or three ejaculations. Finding living spermatozoa always present, I began to lengthen the time at which the ejaculated specimens were to be brought.

"I found, in brief, that spermatozoa are often encountered alive up to the twenty-first day and infrequently as long as the twenty-eighth day. I have no cases in which the vasectomy was proved to be complete in which spermatozoa appeared alive later than the twenty-eighth day.

"These data were accumulated in order to advise patients as to when they would be sterile following vasectomy. It was my desire also to obtain some idea as to what the length of life of a spermatozoon actually is. I now believe this length of life to be twenty-eight days. I have asked many patients to do their best to prevent ejaculation in the interval up to twenty-eight days and to bring in an ejaculated specimen on the twenty-eighth day. In such cases I often find occasional live spermatozoa still feebly moving among numbers of dead ones."[149]

A method of vasoligation and vasotransection without scrotal incision is described by Way and White.[150]

Twyman and Nelson[151] report successful vas deferens anastomosis four years after bilateral vasectomy. Their technic was as follows:

"Under general anesthetic an incision was made over the right vas, and the two cut ends were brought to the surface and freshened to the point where patency could be observed.

a loose hammock loop, and forced the two ends of the vas together; all layers properly approximated. The opposite vas was repaired in like manner and wounds closed." Cameron[152] has successfully anastomosed the vas deferens over a stainless steel tube.[153]

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CHAPTER XVI

THE FEMALE GENITOURINARY ORGANS

INJURIES AND FUNCTIONAL DISTURBANCES

Contusions and Hematomas.—A fall astride a hard object or a blow on the perineum may cause contusion of the labia majora and minora. The swelling may be extremely large and painful but will generally yield to rest and hot fomentations. In some cases the subcutaneous effusion of blood may be so large as to cause a hematoma. In most cases this will absorb spontaneously, but when the collection of blood is large and is fluid, it is best treated by aspiration under strictly aseptic precautions and by the application of a pressure pad.

Wounds and Hemorrhage.—The labia are extremely vascular, and wounds are commonly accompanied by profuse hemorrhage which may be extremely difficult to control. When the injury is only slight, rest and the application of a snug pressure pad will suffice. In many cases, however, it will be necessary to give the patient a general anesthetic and with the aid of a good light and proper assistance to catch the bleeding points with hemostats and ligate them. In some cases packing will be necessary, and when the hemorrhage is very severe, ligature of the bleeding tissue *en masse* may be indicated. "In open hemorrhage from a small wound, if pressure does not control it, the wound may be packed with pledgets of cotton dipped in liquor ferri sulphatis or in tannic-acid powder, and then vaginal packing and vulvar compress employed."[1]

Rupture of the Hymen and Vagina.—A fall upon a picket fence or some other forcible injury may cause tearing of the hymen and even of the vagina itself. In cases of more severe injury, the rectum may be wounded and the peritoneum invaded, a condition which obviously calls for major surgical intervention. The hemorrhage from the hymen may be slight and may subside without ligature. On the other hand, very profuse hemorrhage may result from injury to the hymen. "An instance of troublesome hemorrhage from a slight injury is the persistent bleeding that occasionally follows the small tear of the hymen in the first coitus. On account of modesty and embarrassment the newly married couple hesitate to call in assistance, and sometimes the bleeding persists for hours—until they finally call a physician, who may find the bedding soaked with blood and the bride almost exsanguinated."[1] Small wounds of the vaginal wall require no treatment other than antisepsis and will heal spontaneously. Larger wounds will require careful suture with absorbable suture material to insure approximation of the parts.

Laceration and Relaxation of the Perineum.—Lacerations of the perineum may be the result of external violence or of the traumatism incident to childbirth. Small wounds of the skin in this region will require a few interrupted silk stitches for closure.

Lacerations of the perineum will vary all the way from small rents in the mucous membrane of the vagina to deep tears into the rectum. The tears of

the vaginal mucous membrane are distinctly subjects for minor surgical treatment. Before the placenta has been expelled a few catgut approximation stitches may be placed without any anesthesia. Any stitches placed at this time should not be tied until after the placenta has been expelled, because of the possibility of their tearing during this procedure. In these second degree tears, which extend through the perineal body, deep sutures of silkworm gut are preferable. These are placed 1 cm. apart and at least 0.5 cm. from the edges. Third degree tears, that is, those which go through the sphincter ani muscles and the rectum, and also old neglected tears of the perineum should be regarded as requiring major surgical treatment.

Incomplete Abortion.—The product of conception may be prematurely expelled either as the result of criminal interference or spontaneously. It is not uncommon in either case for some portion of the membranes or of the placenta to remain behind in the uterus. This may give rise to a continuous loss of blood which, if untreated, may cause serious injury to the health of the patient. If this condition is a sequel of criminal abortion, no surgical intervention should be thought of unless the hemorrhage is so alarming as to be of immediate danger to the patient. Practically all criminal abortions are accompanied by the introduction of pathogenic organisms into the uterus. Streptococci and staphylococci are common organisms. Gas gangrene infection by the Bacillus welchii has been reported.[2] Any instrumentation inside the uterus is exceedingly dangerous because of the possibility of spreading the infection into the parts adjacent to the uterus or into the blood stream itself. In these cases rest in bed and watchful waiting comprise the procedure of choice. In many cases the bleeding will subside entirely under this treatment. The patient should be afebrile for a minimum time of five days before operative treatment should be attempted. According to Danforth,[3] the "*indications for curettage* today are practically limited to the removal of the retained products of conception in an incomplete abortion and for diagnosis in an otherwise unexplained hemorrhage.The latter indication usually obtains in older women in whom carcinoma of the body of the uterus may be suspected. After other means have failed, curettage is occasionally useful in young women as a therapeutic measure in menorrhagia. This should be made use of with conservatism."[4]

Zacherl and Richter[5] believe that the late sequelae of abortion are more severe than the immediate results. In 1933 Spitzer[6] estimated that there were 25,000 deaths a year in Germany from induced abortions, primarily from those performed in private homes. Moreover there is always danger of perforation of the uterus and injury to the intestines. For an interesting account of these injuries, see the article by Wright.[7]

In cases of spontaneous incomplete abortion, dilation and curettage should be resorted to promptly if active bleeding is present. It is not very good judgment to permit a woman to lose large quantities of blood day after day in the often vain hope that the hemorrhage will subside. It is far better to empty the uterus surgically. If the bleeding is slight, curettage may be deferred several days in the hope of spontaneous completion.

Dilation and curettage may be regarded as a minor surgical procedure. However, the danger from sepsis and the introduction of pathogenic bacteria into the uterus almost classifies this operation as one of major surgical importance. The operation is best performed under general anesthesia. The external genitalia are completely shaved and they

and a wide area adjacent are then painted with mercurochrome-acetone solution or 2 per cent iodine. By the aid of a vaginal speculum the interior of the vagina is then thoroughly painted with the antiseptic solution. A weighted speculum may then be placed in position and the cervix inspected. If the cervix may not readily be seen, the anterior or posterior lip of it will be grasped with a two-toothed uterine tenaculum and drawn forward to the orifice of the vagina. In many cases a large portion of placenta and membranes will be seen loosely held in the partially dilated cervix and may be withdrawn without effort with a placental forceps or a simple tissue forceps This procedure in many cases is all that is necessary. If no placental tissue is visible at the cervix, it will be necessary to proceed with the dilation and curettage. The cervix is firmly grasped by the upper lip with a uterine tenaculum and drawn down. A long applicator soaked in 8.5 per cent tincture of iodine is gently inserted into the cervical canal as far as it will easily pass. Uterine dilators of the solid type (Hegar dilators) are then carefully inserted in increasing sizes. These are profitably lubricated with mercurochrome solution. It is extremely important to have the cervix and the dilator under firm control. As the larger sizes of dilators are reached a certain amount of force will be required to introduce them into the uterine cavity, and there is considerable danger that the pointed end of the dilator will slip forward and perforate the uterine wall. After the cervix has been dilated it very often will be possible to remove the retained products of conception with the blunt finger, aided by pressure upon the fundus through the abdominal wall with the other hand. If this fails, a small placental forceps is inserted in the uterus, and any bits of tissue which may be grasped are extracted. The final step is the systematic and extremely careful curettement of all surfaces of the endometrium with a large sharp uterine curet. A blunt curet is used by some. It is needless to emphasize the extreme danger of uterine perforation if excessive force is applied. This accident has happened so frequently (cases have been reported in which even intestines have been curetted down through the cervix) that the peril will be known to all. Extreme gentleness should be the watchword in all curettements. After the curettement has been completed packing is usually unnecessary. If the uterus has been emptied, bleeding stops, and the less intrauterine manipulation the better (Danforth). In the unusual case in which packing may be advisable, ½ inch sewed gauze is used. This is best put in place with a uterine dressing forceps, care again being taken not to force the instrument through the fundus of the uterus The tubular mechanical uterine packers with tooth mandarins are preferred by some for this purpose. When more than one strip of gauze is required to pack the cavity, rather than knot the strips together, one may attach them by the method of Spangler:[8] "When the end of the first strip of gauze is approached, the second strip is started from its tube. In the beginning of the second strip, starting about an inch or two from the end and cutting away from the end, one cuts a longitudinal slit slightly longer than the width of the first gauze. Now, holding the beginning of the second strip flat, one brings the end of the first strip up through the slit in the second strip. Then the end of the first strip is passed round under the second strip and up over the opposite side to the slit. The end of the first strip is now passed down through the slit in the second strip in the opposite direction from its first passage through the slit. The loop thus formed is now set by firm tension on all three ends. The two limbs of the first strip are grasped in sponge forceps, and the whole union is introduced into the uterine cavity as with the single strip of gauze. Care is taken to make sure that the open end of the V formed by the first strip is directed toward the fundus of the uterus. The packing is completed in the usual manner. Additional strips may be united in the same manner as needed." The vagina is then packed with 2 inch sewed gauze packing, and the ends of the uterine [illegible] with adhesive tape to the inner aspect of the thigh The ends of the uterine and vaginal packing may be kept separate A sterile vulval pad is applied. Both uterine and vaginal packings are removed twenty-four hours after operation. It is needless to warn against the danger of leaving in the vagina small gauze pledgets.

Foreign Bodies.—(*a*) *Vagina and* (*b*) *Urethra and Bladder*.—The wide variety of foreign bodies which are found in the vagina, urethra and bladder and their methods of removal were discussed in the section on foreign bodies.

In this connection it will not be amiss to warn against the danger of *cervical pessaries*. In reporting a fatal case in which a cervical stem pessary

had been used and in which Streptococcus haemolyticus was found in the uterus and in the heart blood post mortem, Jones[9] says: "The widespread use of different types of cervical pessaries, presumably for therapeutic purposes but in reality for contraception, prompts this report. Physicians are led to believe that these instruments are beneficial to patients suffering with dysmenorrhea, or at least that they are harmless. Both assumptions are false. Within the last few years more than a dozen patients have been seen in the gynecologic service at St. Luke's Hospital with severe pelvic peritonitis and cellulitis due to infections originating about these pessaries." In the case reported by Sussex[10] a gold stem pessary had penetrated the uterus and projected into the abdominal cavity. Hysterectomy was necessary. (See the section on Foreign Bodies.)

Retention of Urine.—Retention of urine is far less common in the female than in the male but may occur following traumatism of the perineum, hemorrhoid operations and perineorrhaphies. (See section on postoperative retention of urine.) The treatment will be catheterization. Catheterization in the female is mechanically a simple operation, but the attention to asepsis and antisepsis makes it a procedure subject to most careful measures. The external genitalia will be washed with soap and water and carefully irrigated with boric acid solution. The sterile gloved hands of the nurse or doctor will then introduce into the urethra a sterile, blunt-tipped glass catheter with a side opening. The catheter is grasped as far back as possible from the tip so that little, if any, of the portion touched by the fingers will enter the urethra. The introduction of ¾ to 2 inches is required to enter the bladder. At the completion of the catheterization the prophylactic instillation of 5 to 10 cc. of 0.5 per cent mercurochrome solution or 10 cc. of a 5 or 10 per cent solution of argyrol solution should be a routine procedure.

INFECTIONS

Cellulitis.—Cellulitis, or diffuse pyogenic infection, may involve the skin and underlying parts of the vulva. It will be treated by rest and hot boric acid fomentations, and in the event that fluctuation indicates abscess formation, incision and drainage will be carried out, with strict attention to antisepsis and hemostasis. Penicillin should be used.

Erysipelas.—Erysipelas occasionally involves the female external genitalia and will be treated under the general rules laid down for that ailment. Crossen[11] says that "considerable relief will be afforded by applying pieces of absorbent cotton, or gauze, soaked in carbolized olive oil (1 or 2 per cent) and the application of an ice-bag outside this dressing." (See the section on erysipelas and its treatment with sulfonamides.)

Plaut-Vincent's Infection of the Vagina.—Arnold[12] reports a case of Vincent's infection of the vagina which followed two weeks after Vincent's infection of the mouth. Smears showed the characteristic spirilla and fusiform bacilli, and the blood showed the picture of agranulocytosis. The treatment, which was followed by recovery, consisted of injections of neoarsphenamine, the use of sodium perborate alternating with hydrogen peroxide as a mouth wash, the employment of a paste of neoarsphenamine in glycerin in the vagina and frequent hot vaginal douches of 1:500 potassium permanganate.

Venereal Diseases.—The treatment of venereal ulcers and gonorrhea involves the use of but few minor surgical procedures. The treatment of

acute gonorrhea in the female should be conservative. Penicillin is of particular value.[13] Fletcher and his associates[14] have found sulfathiazole highly effective. (See treatment of gonorrhea with penicillin and the sulfonamides.) Rest in bed with external cleanliness is important.

When the acute stage is passed antiseptic irrigations and applications are employed, the former frequently being carried out by the patient herself. The treatment of *chronic endocervicitis* includes: puncture of cysts, if they are present, and application of an antiseptic astringent, linear cauterization and, in marked cases, operative treatment, such as the Sturmdorf operation. Chronic gonorrheal endocervicitis occasionally is treated beneficially by the use of dehydrating and antiseptic tampons.

All vaginal discharges in children should be viewed with suspicion. Eighty per cent are due to the gonococcus. Stein[15] has made an interesting clinical investigation of vulvovaginitis. He found that it is an infection which frequently is gonorrheal in origin but may be nonspecific, even in the purulent varieties. The diagnosis rests upon the clinical evidence of the disease and upon the examination of the smear by an expert. Penicillin, particularly, and the sulfonamides will take the foremost place in the treatment. Adler[17] reports favorable results from the use of sulfanilamide. Hoffman and his associates[18] have had excellent results with sulfanilamide.[19] Estrogens in suppositories have been found useful by Te Linde.[16]

Chronic pelvic inflammation has been treated with heat. The apparatus devised by Dr. Charles R. Elliott consists of a distensible rubber bag which is inserted into the vagina and around the cervix and through which a current of hot water is circulated by means of a small electric motor at a constant temperature, regulated by means of a thermostat. The pressure is regulated to distend the vagina.* Its employment is spoken of as the *Elliott treatment.*

After termination of treatment for gonorrhea the patient should be kept under observation for a while, and examinations of smears and cultures and complement fixation tests should be made from time to time.

(For a discussion of lymphogranuloma inguinale [lymphopathia venereum] and granuloma inguinale [granuloma venereum] see the chapter entitled Male Genitourinary Organs.[20])

Abscess of Bartholin's Gland.—A not uncommon sequel of gonorrheal infection in the female is the formation of an abscess of Bartholin's gland. The diagnosis will be readily made by the finding of a red, extremely painful swelling on the labial margin at the site of Bartholin's gland. Fever and other systemic disturbances may be marked. *The treatment of abscess of Bartholin's* gland is incision and drainage. This will be best carried out under general anesthesia, although many of these abscesses may be opened under local anesthesia. A vertical 1 inch incision is made at the mucocutaneous border or through the skin.[21] After the evacuation of the pus the cavity will be loosely packed with plain or iodoform gauze. The vascularity of the labia is likely to cause the unpleasant complication of severe postoperative hemorrhage. One should never content himself that the oozing from the wound will subside with pressure and packing but should scrupulously ligate all bleeding points. Phelan[22] treats the abscess cavity with carbolic acid. Packing will gradually be withdrawn so that the abscess will granulate in from the

* This apparatus is distributed by the Elliott Treatment Regulator Co., 6 East 45th Street, New York.

bottom. Unfortunately, there is a tendency to recurrence, and it will be advisable in some chronic cases to excise the gland completely when the infection is dormant. Excision of the gland in the acute infection stage is inadvisable. Discharge from an abscess of Bartholin's gland or the fistula which results after excision must be regarded as infectious, and nursemaids or others afflicted with this condition must be prohibited from the care of small children, particularly girls, for a long interval of time, at least several months after the smears have become negative for gonococci.

Pelvic Abscess; Abscess of Douglas's Cul-de-Sac.—The diagnosis of abscess of the cul-de-sac is made by the palpation of a tender swelling, just back of the uterus in the vaginal vault. This swelling may be fluctuant. Fever will

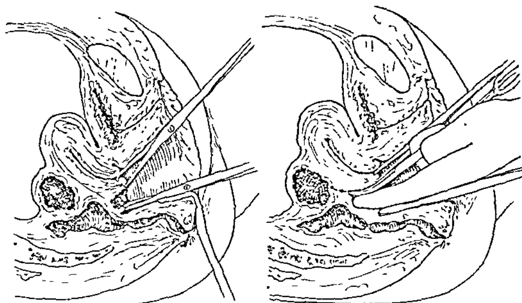


Fig. 238.—Opening a pelvic abscess. *A*, Incision through the vaginal wall. The retractor has been introduced, the cervix caught with a tenaculum forceps and the vaginal wall clipped through just back of the cervix. *B*, Blunt dissection through connective tissue. The retractor has been removed to permit the fingers to be introduced into the vaginal incision, and dissection is now being made through the connective tissue with the fingers and blunt scissors. The arrows show the direction of the dissection (between the abscess and the uterus and not between the abscess and the rectum); each arrow may be taken to represent a forward thrust of the blunt scissors beyond the end of the finger. (Crossen, H. S.: Diseases of Women, St. Louis, C. V. Mosby Co., 1922.)

be present. Only a bulging abscess should be opened. Dupuytren's abscess is an "extraperitoneal parametrial abscess forming a prominence above Poupart's ligament."[23] The procedure of opening a pelvic abscess is as follows: The patient is examined under general anesthesia in order to ascertain the most fluctuant portion of the abscess. A vaginal speculum is introduced, and the posterior lip of the cervix is grasped with a tenaculum and drawn forward. The vaginal mucosa is then carefully cut through immediately behind the cervix, and by blunt dissection with scissors and finger the connective tissue behind the uterus is separated until the dense infiltration and resistance indicate that the wall of the abscess cavity has been reached (Fig. 238). With a sharp-pointed scissors a puncture is made into the center of the inflammatory mass. Extreme care should be taken to avoid puncturing

remove chronic inflammation which may be a precancerous lesion; and (3) to eliminate a possible focus of infection.

"In treating leukorrhea the etiology must be established. Infection of Skene's and Bartholin's glands due to a gonococcus infection may be the source of the discharge, and treatment must be directed against a specific type of infection. The discharge may be due entirely to a vaginitis resulting from a change in chemical reaction of the secretion from the cervical mucous glands, or to the presence of the Trichomonas vaginalis. The most frequent cause of discharge is, of course, a cervicitis primary or secondary to salpingitis.

"Chronic cervicitis frequently is characterized by a chronic erosion and this may be the site of an epithelioma. An early carcinoma may be easily mistaken for a simple erosion and unless a biopsy is done, the diagnosis is not made until considerable valuable time has been lost for the patient."

The technic of cauterization of the cervix is described by Graves[26] as follows: "The cervix is first dilated, the lips being held apart as widely as possible by double hooks, anterior and posterior. Deep incisions are then made into the endocervical tissue parallel to the canal and radiating from the center. The incisions should be carried as far as the internal os. If there is eversion or erosion the incisions may be carried out into the healthy membrane." (See Figs. 240, 241.)[27]

Trichomonas Vaginalis Vaginitis.—Allen says,[28] in part:

"Trichomonas vaginitis is one of the most frequent forms of vaginal infection. At least in private practice it is much more common than gonorrhea. The differential diagnosis of vaginal infections is not as accurate in general practice as it should be. These inaccuracies are probably due to our previous teaching concerning the high incidence of gonorrhea and the almost universal use of stained preparations for the detection of the gonococcus. Only in recent years have the other vaginal infections, such as trichomonas and yeast, been given their proper place in the list of vaginal disease.

"The differential diagnosis is of the utmost importance from the standpoint of treatment, prognosis and psychic response of the patient. . . . An unlubricated speculum should be introduced into the vagina and smears made from the cervical canal. When the speculum is withdrawn all visible secretion from the anterior and posterior fornices is picked up by the posterior blade of the instrument. A portion of this discharge is either mixed with a small quantity of warm normal saline or transferred directly to a slide covered with a cover slip and examined microscopically. Following this any material expressed from the urethra should be smeared for staining. It is important that this material be obtained before digital examination is begun because lubricants, especially glycerine, quickly stop the movements of the flagellates. It is also important to ascertain whether there has been any recent vaginal medication, as even a plain water douche may interfere with the motility of the trichomonads. If organisms are not found on the first examination, subsequent investigations either following the next menstrual period, which is the most likely time, or when the symptoms have become more severe, may reveal them in abundance. Even when trichomonads are [illegible]

[illegible]

The numerous special staining methods thus far reported for trichomonads have not proved [illegible]

sugar in the urine should be done. . . . The most prominent complaint is that of a profuse, watery, irritating vaginal discharge, which produces itching and burning of the vulva. Trichomona vaginalis may occasionally be found in a thick, tenacious discharge that seems to come directly from the cervical canal. The usual watery discharge is greenish in color

portant in the therapy. Cleansing of the vaginal walls followed by the topical application of medicinal substances such as the dyes or arsenical preparations continued over long periods of time are an essential part of the treatment."[29] Brady and Reid[30] have had success in the treatment of vaginitis due to Trichomonas vaginalis following the introduction of viable lactic acid-forming bacilli into the vagina. Danforth[31] advises (1) cleansing of the

the next morning, (6) insertion of another suppository the next night, with douching the following morning (7) and office treatment in two days.

Ulcers of the Vulva and Vagina.—Crossen[32] divides ulcers of the vulva and vagina into seven classes.

Simple Ulcers.—These are due to the ordinary pyogenic organisms and other common irritants. The "ulcus vulvae acutum," according to Scherber and Lipschuetz, will give an almost pure culture of Bacillus crassus, or B. vaginalis of Doderlein.[33] Levin[34] says the exciting agent is B. crassus, which is a saprophytic organism and is not infectious. He

talcum powder, and aluminum acetate vaginal douches should be prescribed for from four to six weeks to prevent recurrence. Stearate of zinc or bismuth subgallate may be used as

cent copper sulfate solution will be useful (Crossen)

Chancroid.—This is an infectious ulcer caused by the Ducrey bacillus and transmitted almost exclusively by sexual intercourse. Twenty-four to forty-eight hours after infection a small pustule with an inflammatory base appears. In several days or a week an ulcer will have formed. This ulcer has sharp, punched-out margins and a necrotic base. It is surrounded by some inflammatory edema. The ulcer increases in size more rapidly in the vagina than on the external genitalia. The course lasts two to three weeks, A secondary ulcer is likely to develop by autoinoculation, a characteristic of chancroidal ulcer. The

applied and then a carbolized vaselin ointment.

Syphilis.—The chancre is the primary lesion of syphilis. The

by the demonstration by darkfield microscopic study of

. As

the

Tuberculous ulcers begin as single or multiple nodules which break down into ulcer formation. These ulcers may coalesce until an extensive area is involved. The diagnosis is confirmed by the finding of the tubercle bacilli. *x*-Ray and radium are used in the treatment, and excision may be employed for smaller lesions. For generalized accompanying tuberculosis, general systemic measures are to be employed.

Granuloma Inguinale.—The diagnosis and treatment of granuloma inguinale have been described elsewhere.

Malignant Disease.—Malignant disease does not belong in the realm of minor surgery.

Ulcus Rodens Vulvae.—This is a destructive chronic ulcer which cannot be placed in any of the preceding classes. The treatment is that of simple ulcer plus iodides and, in some cases, *x*-ray.

TUMORS

Benign.—*Lipoma.*—The vulva not infrequently is the site of a lipoma which may attain considerable size. The smaller tumors require no treatment, but the larger ones, because of the inconvenience occasioned by their size, will require removal. This may be accomplished under local anesthesia with strict attention to antisepsis and hemostasis.

Retention cysts, fibromas, lymphangiomas, myxomas and *angiomas* are other benign tumors which may be found upon the vulva.

According to Brady:[35] "Fibromata of the vulva are not common. Fewer than 175 have been reported. The majority arise in the subcutaneous connective tissue, but quite a large group originate in the extraperitoneal portion of the round ligament.

"These tumors usually appear at first as firm, smooth, round or oval nodules under the skin. They may become pedunculated as they increase in size, and may have a marked resemblance to a male scrotum. They are firm to palpation unless the circulation becomes impaired. They vary from small nodules to tumors of enormous size. It has been shown that nearly one-fifth become sarcomatous. The size of the tumor may cause symptoms or there may be no symptoms unless malignant change or inflammation occurs."

All of these tumors may be removed under local anesthesia, but in the more vascular ones very careful attention must be given to hemostasis.

Condyloma acuminatum (papilloma), sometimes called an *acuminate wart,* is a benign tumor of epithelial origin. These tumors are multiple in origin and may be so extensive as to cover the entire vulvar skin. They are practically pathognomonic of gonorrheal infection. These warts are satisfactorily treated by being snipped off with the cautery blade (Taussig). Wolters and Hesseltine[36] have successfully treated condyloma acuminatum with radium.

various preparations recommended for the treatment of Trichomonas vaginalis infestation. One that has recently been recommended is the use of a douche of phenol mercuric nitrate, 1:10,000, in water, the douches being used once or twice a day. If vaginal intestinal parasites

down the end of an a
acid on each of the
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use of potassium permanganate sitz baths 1:4000 twice a day will be found of great value.

Urethral Caruncle.—At the external urinary meatus, particularly in elderly women, there often occurs a benign polypoid overgrowth of the mucous

membrane. Olcott[39] made a careful study of 23 cases of urethral caruncle in the female and summarized his study as follows:

"1. The epithelium of caruncles of the female urethra frequently shows enough infolding to make their actually benign nature appear doubtful to one who is not familiar with this particular structure.

"2. Compound acinar glands similar to those described by Skene are frequently present in the female urethra. They are found in 17 of our 23 cases.

"3. It is suggested that these glandular structures may be an important factor in the formation of caruncles."

These urethral caruncles have a red, velvety appearance similar to that of fresh granulation tissue and are elevated from the surrounding surface. They are very fragile and bleed easily. They are of two types—the papillomatous and the angiomatous. The former are far more common and are covered with stratified squamous or transitional epithelium supported by a connective tissue framework.[40] They are exceedingly irritating to the patient. Pain, with and without urination, burning and frequency are characteristic. The treatment of urethral caruncle has evoked some difference of opinion. It is prone to recur. The very small caruncles are very satisfactorily treated with cauterization with fused silver nitrate. The larger ones are treated either by excision or by fulguration. Excision of a urethral caruncle is rather difficult to perform under local anesthesia, and general anesthesia would be the choice. Te Linde[40] says: "For complete removal of the caruncle surgically, a circular incision may be made around the meatus and while gentle traction is made on it, the urethral membrane is dissected free in a way analogous to the Whitehead operation for hemorrhoids. The freed distal portion of the urethra is then excised beyond the point of origin of the caruncle and the shortened urethra sutured to the edge of the circular incision. If the caruncle is small it may be possible to remove it completely by resecting only a small part of the distal portion of the posterior wall of the urethra. A disadvantage to the surgical treatment is that in case the urethra is too much shortened, partial incontinence may result. It is important to remove all of the caruncle as they have a tendency to recurrence. The advocates of surgical diathermy in the treatment of urethral caruncles contend that this method of treatment is more simple to carry out and is accompanied by less hemorrhage. Where fulguration is carried out, it may be advisable to clip off the caruncle and to fulgurate the base."[41]

Urethral Polyp.—Wynne[42] reported a case of pedunculated urethral polyp. His patient had a fiery red, insensitive polyp, measuring 10 by 8 by 3 mm., which dangled at the end of a pedicle 1 cm. in length. It was attached to the posterior urethral wall 0.5 cm. above the external meatus. The polyp was removed with a small cautery knife.

Cervical Polyp.—Polypoid growths may occur on the cervix uteri. These polypi are bright red, friable, pedunculated growths which may be an inch or more in length. They are adenomatous or fibrous pedunculated tumors arising from the cervix. They are generally benign, but malignant change may occur. They may give rise to troublesome bleeding and vaginal discharge. The treatment is surgical and consists of their removal. This may be done under local anesthesia or, owing to the low sensitivity of the cervix, without any anesthetic. These polypi may be removed by slow torsion, or they may be removed by the method described by Martzloff.[43] This surgeon, in the

cases in which the attachment is high in the cervical canal, uses a simple wire snare tonsillotome (Fig. 242). The cervical canal is dilated, and the wire is slowly tightened over the base of the pedicle. If oozing occurs, plain or iodoform packing is left in place for forty-eight hours. Or the polyp is simply excised at its base or cut off with a scissors. Simply twisting the polyp off is sometimes practiced. *The control of bleeding is particularly to be emphasized* in this connection. Wherever possible Martzloff advises a preliminary trans-

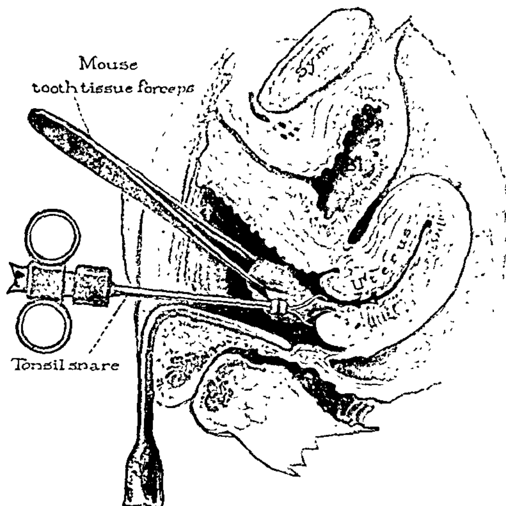


Fig. 242.—Schematic sketch in sagittal section to show method of removing a cervical polyp with an ordinary tonsil snare. The wire loop of the snare has been slipped over the mouse tooth tissue forceps which steadies the polyp. The wire loop has been shortened preparatory to crushing the pedicle. In some instances it may be helpful to steady the cervix with a Cullen three-pronged tenaculum or some similar instrument. (Martzloff, K. H., in Lewis, D.: Practice of Surgery, Hagerstown, Md., W. F. Prior Co., Inc., 1928, vol. 10, chap. 14, p. 10.)

fixation-ligation of the pedicle. It will be well to have good light and good assistance to insure the hemostasis and to keep the patient under observation for several hours, or longer, after the procedure. The writer once removed such a polyp in his office and had the embarrassing experience of having his patient taken to the hospital in the middle of the night by another physician because of profuse postoperative hemorrhage.

Glass[44] removes a cervical polyp as follows:

"With the patient in the knee-chest position and using a Sims vaginal speculum which elicits the best exposure of the cervix, though good exposure can be obtained with the patient in the lithotomy position, and a bivalve speculum in place, the vagina and cervix are gently [illegible]

polyp it is advisable to be very gentle in the traction so as not to tear the polyp off its attachment because of the danger of hemorrhage, but to use a moderate amount of tension and then with a cautery tip at a cherry-red heat slowly transect the pedicle until the polyp has been severed. The heat from the cautery safeguards against hemorrhage by coagulating the blood vessels cut across."

Cervical polypi are practically always benign, but this does not excuse the surgeon from the responsibility of having an accurate histologic diagnosis made.

Condylomas are excrescences which are found in the neighborhood of the labia majora, clitoris and perineum. Those which are flat and moist are due to secondary syphilis and yield promptly to antiluetic treatment. The treatment of the others is described in the section on benign tumors.

Vaginal Cysts.—Cysts of various types are occasionally found in the vagina. They vary "from the size of a pea to that of a cocoanut, but the great majority are less than 3 cm. in diameter."[45] The removal of a large vaginal cyst is a major surgical procedure. Small ones may be readily removed under local anesthesia (0.5 per cent procaine solution).

Cysts of Bartholin's Gland.—As a consequence to infection, generally gonorrheal, the outlet of Bartholin's gland may become occluded, and in consequence there will occur a cystic accumulation of the secretion of Bartholin's gland. The resulting cyst of Bartholin's gland may attain the size of a marble or larger. When not acutely inflamed, it may be easily removed, but attention must again be called to the necessity of strict hemostasis. Removal is best done in the operating room under general anesthesia.

Cattell[46] says: "A cutaneous method [illegible]

[illegible] mucous membrane. Rarely is the cyst ruptured since the usual opening of the duct is closed or the cyst would not have formed.

"Beginning in the deeper layers, a continuous fine chromic catgut suture is used with a swaged needle running the full length of the incision and carrying it back and forth three times (Fig. 243 [illegible]
cuticular sut[illegible]
restoring the [illegible]
243, *d*).

"These patients may get up the following day and return home on the second day, thus having a very short period of disability. After the fourth or fifth day, sitz baths may be used if there is any discomfort."

Cysts of the canal of Nuck are analogous to hydroceles of the cord in the male. They are cystic collections of fluid enclosed in a peritoneal covering. They are found associated with the round ligament in the inguinal region. It is said that this condition may disappear spontaneously in young girls. The treatment is excision under local anesthesia.

Elephantiasis is a chronic disease of the lymphatics, characterized by hypertrophy of the skin and the subcutaneous tissue. This "stasis hyper-

trophy" (Crossen) "may be due to persistent ulceration with resulting scar tissue or to an obstructive disturbance in the inguinal lymph glands, or to a local invasion of the lymphatics by a parasite (filaria)." The legs and the external genitalia are principally affected. The vulva may as a result become ulcerated and fissured.

The treatment necessitates cleanliness and use of mild antiseptics, such as those described in the treatment of ulcers. The treatment of the larger masses is excision, preferably under general anesthesia. The smaller masses may be removed under local anesthesia.

Malignant Tumors.—*Carcinoma* and *epithelioma* of the female genitalia are major surgical problems. However, the diagnosis of carcinoma of the body

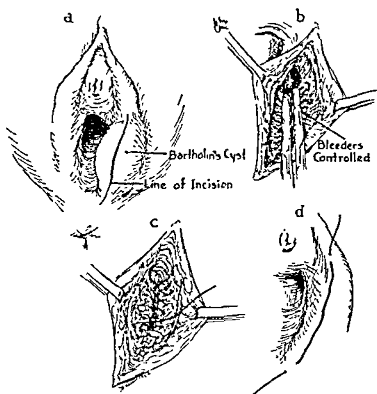


Fig 243.—*a*, The cutaneous incision is shown. *b*, The cyst has been excised and bleeding controlled by clamps. *c*, A continuous suture is used to control bleeding and to obliterate the dead space. *d*, A subcuticular suture completes the closure (Cattell, R. B.: S Clin. North America 22: 837, 1942.)

of the uterus is usually made from histologic examination of uterine scrapings. The procuring of the scrapings is a minor surgical procedure. Women, particularly those who are elderly, who suffer from otherwise unexplained metrorrhagia must be suspected of having carcinoma. In these cases dilation and curettage will be carried out in the manner described previously. In the majority of gynecologic clinics, carcinoma of the cervix or inoperable carcinoma of the fundus uteri, certain fibroids of the uterus and so-called "myopathic bleeding" of the uterus occasionally are treated by the insertion of radium into the uterine cavity. Most patients with carcinoma of the fundus uteri require operation. For endometrial biopsies the suction curet apparatus of Novak[47] and the instrument of Randall[48] are valuable.

Martzloff[49] says: "Clinically recognizable early cancer of the vaginal portion of the cervix, as physicians have been taught to recognize it, usually presents itself as a red, firm, irregular, somewhat elevated circumscribed process, situated ordinarily in the neighborhood of the external os. It generally bleeds readily on light manipulation with a soft cotton pledget and on palpation may feel indurated, although induration as a highly diagnostic sign has probably been greatly overemphasized. It is a lesion that should at once arouse one's suspicion as to its malignant character, and to discover it no apparatus is necessary that cannot be found in the office of any qualified physician. The obtaining of tissue for histologic examination without undue delay is imperative, so that one's diagnosis may be unequivocally established and treatment advised.

"The obtaining of biopsy material from such a suspicious area on the vaginal portion of the cervix is in itself so important a matter that it cannot be overstressed. It may sound trite to say that material for biopsy must contain cancer before cancer can be revealed under the microscope. Most pathologists can testify to personal experience with tissue submitted to them from cancer-afflicted patients which either showed no cancer or was of debatable character while full-blown carcinoma existed a few millimeters from the site of the specimen. Tissue removed from a small circumscribed area suggestive of cancer should include both material from the suspicious area and a generous amount of adjoining normal-appearing tissue. The block so obtained should be rectangular or nearly so . . . and should be immediately fixed in solution of formaldehyde or other suitable fixing solution. If the material is obtained and [illegible]

[illegible]

the endothermy loop may be entirely unsatisfactory. The advisability of curetting the surface of the process as has been recommended is also a dubious procedure. Ordinarily there can be little excuse for such haphazard methods when the lesion is small, circumscribed and primarily a diagnostic problem.

"When the area under suspicion is more diffuse or located on a cervix that otherwise merits some form of operative [illegible] bined with amputation, as descr[illegible] obtaining material for biopsy [illegible] scalpel or the endothermy current is employed for this purpose probably matters little. However, if the latter is used one should allow for destruction by heat along the margins, where the fragment of tissue becomes unsuitable for histologic study. When a tumor is large and its [illegible]

[illegible] probably true that more advanced cancer possesses no distinctive or grossly pathognostic appearance. Its clinical recognition rests on the fortuitous circumstance that most ulcerating, indurated tumors of the portio are cancer."

Schiller Test.—Physicians who treat lesions of the cervix should be familiar with the early diagnosis of carcinoma. The *Schiller test* will prove useful in making this diagnosis. Schiller[50] discovered that the glycogen in the normal superficial epithelium of the cervix stains brown with iodine but that the areas of early carcinoma are devoid of glycogen and therefore do not stain brown. This procedure enables one to find an area suitable for a biopsy. The solution used is iodine, 1; potassium iodide, 2; and water, 300. Galloway[51] calls attention to the fact that this is Gram's solution, not Lugol's solution, as referred to by Schiller. Lugol's solution is too strong and is unsatisfactory. Schiller[50] describes the technic and interpretation as follows:

"A cervical speculum is placed in the vagina and out of a small cup with a long spout about 10 to 15 cubic centimeters of Lugol's solution is poured and spread with a tampon over the cervix and left in the vagina for about a minute. The iodine solution is then sucked off with a tampon, the cervix and vagina are cleaned of the excess liquid, and gently wiped. It is very necessary that the solution should moisten the entire cervix and that no fold should prevent the entrance of the liquid as that might cause wrong diagnoses. If the epithelium shows an unstained spot we must be suspicious of cancer and the tissue here must be

[illegible]

the speculum. Such traumatic desquamations are easily to be diagnosed by their form, as they resemble narrow sharp and straight line scratches."

Galloway,[51] who worked with Schiller, says: "When an iodine-free area is seen, the tissue needed is only epithelium, not the underlying tissue. It can be obtained in several ways. I prefer a small, sharp, cup-shaped tissue punch. The raw surface is then cauterized with the electric cautery. If bleeding occurs, the vagina can be packed with gauze for eight to twelve hours. The small scrapings are more difficult for the technician to work with but they can be prepared in paraffin blocks much quicker, especially if one puts them in Carnoy's solution which contains no water and from which they can be taken quickly into paraffin. This solution causes marked shrinking however."

The specimen is best obtained, if possible, at the border between normal and glycogen-free cells. Schiller[52] has since described the application of his test to the portio uteri. Smith and Pemberton[53] present 16 cases corroborating Schiller's work. Henriksen[54] says, "The Schiller test is undoubtedly of some value in the diagnosis of early cancer; whether it is a specific for the absence of the cancer is questionable."[55] The Schiller test is used less at the present time than it was a few years ago. Many clinics have discontinued its use entirely.

CONGENITAL AND ACQUIRED DEFORMITIES

Imperforate Hymen.—Some girls are born with an intact hymen which completely closes the vaginal orifice. This causes no symptoms until the onset of menstruation, when, despite the presence of other menstrual symptoms, there is failure of the flow to escape to the exterior. The hymen should be let alone until the onset of menstruation brings about a damming back behind the hymen and the formation of a hematocele, which fills the vagina and may distend the uterus and fallopian tubes so greatly that they can be palpable above the symphysis. I saw a patient once with such marked abdominal distention that a diagnosis of ovarian cyst had been made. The bulging hymen was fortunately discovered before the girl was sent to the operating room. Attention to the condition is attracted by the delay in onset of menstruation and by a darkened and bulging hymen. The condition is readily relieved by cross incision through the hymen, generally best performed with the patient under general anesthesia and with careful attention to hemostasis. The vagina should not be irrigated.[56]

Atresia of the Vagina.—Atresia of the vagina is congenital narrowing or partial closure of the vagina. According to Wharton,[57] it is rarely found except in cases of double uterus, and it is generally accompanied by amenorrhea. The treatment, in the few cases in which it may be indicated, is a major surgical procedure.

Varicose Veins of the Vulva.—These rarely require surgical treatment. When extremely large, however, they may be excised, preferably with the patient under general anesthesia and with the usual strict precaution in regard to hemostasis which this region requires.

Prolapse of the Uterus.—Descensus uteri, or prolapse of the uterus, may be so marked that the uterus will present at the vaginal orifice or even completely escape from the vagina. The treatment of choice in this condition is a major surgical operation, preferably the Manchester operation (parametrial fixation) or vaginal hysterectomy with utilization of the uterosacral and broad ligaments and the pubocervical fascia. In cases in which this is impossible, minor surgical treatment affords considerable relief by the application of a pessary or truss, the large bell of which fills the vagina and holds the uterus in place. A simple hard rubber ring of doughnut shape and suitable size is the most frequently useful. It should be changed at least every two months. The Menge pessary is useful.

Vesicovaginal Fistula and Rectovaginal Fistula.—These fistulas require major surgical treatment.

Pudendal Hydrocele.—In this condition there is a collection of fluid in a canal which may have persisted along the round ligament, the internal end of the canal being closed. It corresponds to hydrocele of the cord in the male. The injection treatment is uncertain and unsafe. The treatment of choice is excision.

Stricture of the Urethral Meatus.—Boyd[58] says that "in the female, congenital stricture of the urethral meatus seems to have been almost entirely overlooked, and for many years dilatation has been employed instead of the clearly indicated meatotomy. Such a narrowing is often responsible for pyelitis in little girls. It certainly predisposes to some urinary infections, as is clearly demonstrated in certain cases by the prompt disappearance after meatotomy of an infection that has been resistant to all the measures usually employed in treating urinary infections."

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CHAPTER XVII

THE ANAL CANAL AND RECTUM

METHODS OF EXAMINATION; HEMORRHAGE; WOUNDS

Methods of Examination.—In all afflictions of the anal canal and rectum the external region should be first carefully inspected. This will be conveniently accomplished with the patient lying in the semiprone Sims position, with the upper part of the legs acutely flexed. The buttocks then may be spread apart and the patient instructed to relax and not bear down. Preferable is a proctologic examination table on which the patient lies prone with the hips elevated. After the patient is in position, the table is tilted so that his head is down and his trunk is nearly vertical. With the patient in this position, the anal canal and rectum are best examined, and external hemorrhoids and fissures readily noted. The gloved and well lubricated finger then will be inserted into the rectum. This must be done slowly and gently and in the proper direction, so as not to excite pain and spasm of the anal sphincter. Internal hemorrhoids are rarely palpated, but the presence of foreign bodies or firm neoplasms, as rectal polyps, adenomas or carcinomas, will be made out. When instrumental examination with the anoscope, proctoscope or sigmoidoscope is employed, it is necessary to prepare the patient with one or more cleansing enemas. The ordinary noninflating anoscope or proctoscope is well lubricated and gently inserted into the rectum while the patient is cautioned to bear down, and the instrument is inclined backward toward the sacrum at the proper angle. The mandarin of the instrument is then withdrawn, and with the proper illumination the interior of the lower rectum will be visible. As the proctoscope is withdrawn, the collapsing walls of the [illegible] [illegible] is used and also certain types of proctoscope, the external orifice of the instrument is closed with a glass window, and the lower portion of the bowel is inflated with air. By this means a larger surface of rectal mucosa is inspected, and a better idea of the interior is obtained.[1] Extreme caution must be exercised in the introduction of the proctoscope and similar instruments. Goldman[2] cites a case in which after the proctoscope was introduced by a physician the patient shrieked with pain and collapsed. "He was rushed to his home and put to bed with a diagnosis of gas pains. After twenty-four hours of agony and several colonic irrigations under the physician's orders, the patient was transferred to a local hospital." Operation disclosed a perforation about the size of a quarter on the right anterior surface of the rectum about 6 inches above the anus. The perforation was closed and drainage instituted, but the patient died of general peritonitis.

Local Anesthesia in Proctology.—Inasmuch as *local anesthesia* is very satisfactory in operations for chronic fissure-in-ano, hemorrhoids, polypi, prolapse of the rectum, benign tumors, incontinence of the sphincters and

certain types of fistula-in-ano (David), it is thought that a description of it would be proper at this point. The following methods are used and described by David:[3]

"The evening before the anesthe...
is gi...
The...
cont...
of causing trauma. No preliminary sedative is given, as it has been found that vomiting occurs in about 20 per cent of the patients receiving preliminary sedatives. The patient is in a position for lithotomy with the knees resting in supports that prevent excessive flexion of the thighs and discomfort from pressure. A 10-cc. rectal syringe with a right-angled adapter allows the needle to be introduced into different planes by simple rotation of the syringe, and at the same time permits the operator's hand holding the syringe to be out of line of vision in the field. Three lengths of Record needles are used, the small size for intradermal wheals, and a 5- and a 10-cm. length for deeper structures. These needles must be kept sharp and free from rust. The practical significance of the nerve supply in regard to

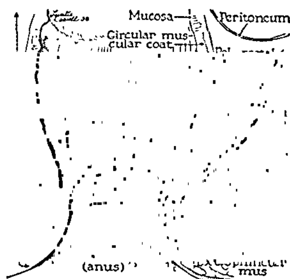


Fig 244.—A diagrammatic representation of the anorectal canal (coronal section). (Nesselrod, J. P., in Christopher, F.: Textbook of Surgery, ed. 4, Philadelphia, W. B. Saunders Co., 1945, p. 1084)

anesthesia by injection is that the internal pudic nerve breaks up into many fibers before entering the field and that the most sensitive area is the region of the mucocutaneous line in the anus. With the finer needle, intradermal wheals are raised about two fingers in breadth from the anus on the right and left side (Fig. 245, *a*). The production of these wheals is painful, and the patient should be warned of the needle puncture. These white wheals raised in the skin produce an instantaneous pressure anesthesia and can be used as sites for the reintroducing of needles, without pain to the patient. The 5-cm. needles are now put on the filled syringe and introduced by way of one of the lateral wheals through the skin in the subcutaneous tissue. Novocain is then injected under the skin with the needle ... The process...

sary to keep the plunger of the syringe in constant motion in order that a pressure anesthesia may be produced in front of the advancing needle The point of the needle should be kept in constant motion in order that the anesthetic may be distributed evenly and no great amount injected into a small vessel, should one be punctured. This procedure should take

the tip of the finger can be gently hooked around the upper border of the internal sphincter, which lies just below the easily palpable levator ani insertion. The long needle is now inserted through one of the lateral wheals and pushed forward just outside of the margin of the external sphincter muscle. Anesthetic solution is constantly injected until the end of the needle is just opposite the end of the finger in the rectum (Fig. 245, *b*). The needle is not palpated by the finger in the rectum, as it is about an inch away from the bowel. The needle is now withdrawn so that the syringe may be refilled by an assistant. The index finger should remain in the rectum until the anesthesia is completed. The same process is now repeated

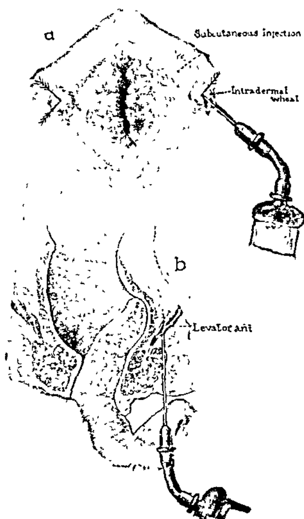


Fig. 245.—Local anesthesia for minor surgery of the rectum. *a*, Lateral intradermal wheals made by injection of 0.5 per cent novocain under the papillary layer of the skin.

ried out around
tum and Anus,
, vol. 5.)

through the same wheal, except that the point of the
posteriorly, so that a wall of ane
peated on the opposite side, abo,
used on each side. The skin over
was injected subcutaneously at the start, so the long needle is introduced

time and will consume about 90 to 100 cc. of 1 per cent [illegible]
insertin[illegible]
The op[illegible]
anesthesia will last about two and one-half hours."

Prolonged Anesthesia.—Burt and Rennie[4] say: "Our principal desire in the selection of an anesthetic for anal operations is to establish instantaneous and complete anesthesia, with prolonged effect to relieve the pain for at least 10 to 14 days. After this time has elapsed, granulation tissue has covered the sensory nerve terminals, and there is no longer need for analgesia.

"The effect of water soluble anesthetics—novocain, for example—is of too short duration to provide the desired effect. The use of anesthetics in oil provides quite a satisfactory means of eliminating or greatly reducing pain and tenderness after operations for chronic anorectal pathology. Yeomans, Gorsch, and Mathesheimer in 1927 introduced the use of anesthetics in oil, and thereby made an exceedingly important contribution to proctologic surgery. Since that time, this method of administering anesthesia has been improved and used in various forms throughout the world.

"The effect of this type of administration is instantaneous and complete. The duration of the anesthesia is difficult to determine because of the difference in the reactions of patients. Conservatively, the duration of good analgesia may be said to be 2 to 3 weeks.

"The oil should not be injected into the epidermis, for an oil in the skin will cause a pressure necrosis. In the absence of frank infection, it may be introduced safely into the subcutaneous or deeper structures. There should be no pooling of the oil; this is assured by constant progress of the needle as the oil is injected.

"We have used benacol, anucaine, nupercaine, butecaine, and neothesol, as anesthetic agents. We have had the most satisfactory results with neothesol, the component parts of which are:

	Parts
"Procaine base...	1
Methyl methylene para amino phenylformate	2
Hydroxbenzocarbinol	
Refined French almond oil—q.s.ad.	

"*Amount of anesthetic agent.* In general, 15 to 20 cubic centimeters of the oil anesthetic agent is adequate for most anal operations. However, 25 cubic centimeters may be required for hemorrhoidectomy. Although the amount of anesthetic material will vary with the extent and location of the pathology, the following general distribution may be used in the case of a fissure of the anus. 3 c.cm. subcutaneously on each side; 3 c.cm. in the subcutaneous and deep external sphincter on each side; 3 c cm. underneath and around the local lesion."

These authors add: "Great care must be exercised in the use of this anesthetic, because of the potential danger of infection and peri-anal necrosis Much experience is required for its proper management."[5]

Hemorrhage from the Rectum.—*Hemorrhage from the rectum[6] should always be the subject of most careful inquiry*, as not infrequently the cause of its origin may be a serious ailment. Hemorrhage from the rectum may be brought about by malignant growths, by hemorrhoids, by ulcerative colitis, by foreign bodies or by wounds. It is important to make an accurate diagnosis as to the cause of the hemorrhage, as naturally the treatment will vary considerably. The blood of hemorrhage from the lower part of the rectum is always bright red, in distinction to the black, tarry blood from hemorrhages higher up in the intestinal tract.

Wounds.—The rectum may be wounded by a fall astride a sharp object, such as a point on a picket fence and the like.[7] Pratt and Jackman[8] review 20 cases of perforation of the rectum by the tip of an enema nozzle. They say: "Perforation of the normal bowel of a conscious patient can take place without the patient's feeling much pain and without the use of much force." More than half of the perforations occurred in patients 55 years of age or

older. The mortality rate was 40 per cent. The measure of utmost importance in this connection is the determination beyond the shadow of doubt as to whether or not the object that has penetrated the rectum has perforated into the peritoneal cavity or if there is possiblity of fecal infiltration of the perirectal planes of cellular tissue. It is essential to have free exposure of the site of the injury by anal dilation or, if necessary, by incision. Palpation of the rectal wound will not suffice; it must actually be seen. The bleeding points will be either ligated singly, or they will be controlled by mass sutures. When it is suspected that wounds of the rectum may have caused an invasion of the peritoneal cavity, the exact site of the wound in the rectum must, if possible, be determined by proctoscopic examination. Its size and, if possible, its depth will be noted. If there are signs of peritoneal irritation, such as pain, rigidity, vomiting, fever, increase in pulse rate and leukocytosis, exploratory laparotomy should be at once carried out.[9] Small wounds of the anal canal or lower part of the rectum will heal kindly without suture. It is desirable to avoid sutures. Ligatures may be used to check hemorrhage. It is usually best to débride the wounds and leave them open. The likelihood of infection is great in the rectum, and most wounds will heal better without suture. In all cases in which the sphincter has been severed it will be advisable to attempt to approximate the ends by suture. This procedure is best effected under caudal sacral block or, less suitably, general anesthesia and may call for as much resourcefulness and skill as a major surgical procedure. The rectum may be injured by the faulty administration of an enema.[10]

Pneumatic Wounds.—Of recent years there have been reported in the literature a number of serious or fatal injuries resulting from the vicious habit of factory employees of placing at or near the anus the nozzle of a pneumatic pressure hose. The air is forcibly injected into the intestinal tract and has been known to burst the intestine at various places. These injuries always belong in the field of major surgery.

Koontz[11] has reported a very interesting case in which there was a gaseous cyst in the ischiorectal space. This cyst apparently had arisen from a minute traumatic rupture of the rectum during a polo game. The small rectal opening closed at once. The cyst was incised from the outside and healed promptly by granulation.

Wounds from Treatments or Applications.—Unskilful passage of an anoscope or proctoscope may wound the rectum. Unskilful packing or the too forcible introduction of a sharp enema nozzle may bring about the same result. The inadvertent loss in the rectum of the nozzle of an irrigating outfit may result in traumatism and, if the nozzle is left too long, ulceration of the rectal wall.[12]

Foreign Bodies in the Rectum.—These have been described in the section on foreign bodies.

Impacted Feces (Coprostasis).—In patients who are extremely constipated or who because of painful conditions about the anus deliberately refrain as long as possible from bowel movements, the feces in the rectum may become hard and impacted. The condition may be so severe that the patient actually will be unable to expel the fecal material or the efforts to do so will be so painful that he will not have the courage to persist in them. The treatment consists of the digital breaking up of the impaction. In severe cases this will require anesthesia.

In his complete discussion of this subject Drueck[13] says the following enema may be used by the patient himself:

Glycerin	2 drams
Oxgall (inspissated)	2 drams
Soapsuds	8 ounces

"This enema is given slowly with low pressure and retained as long as possible. It may be repeated every three hours." Drueck[13] also says: "Good results are often obtained by using 4 ounces each of hydrogen peroxide and water, used as an enema and retained as long as possible. If the mass is low in the rectum, the mixture may be injected directly into it by means of a long syringe nozzle. This treatment may be repeated every three hours, and often the mass is so disintegrated that the next day it can be washed out with irrigation. The peroxide, when brought in contact with organic matter, liberates oxygen bubbles, which often soften and break up the impacted mass. Of course, this method is only applicable where the accumulation is in the rectum or sigmoid."

INFECTIONS AND FISTULAS

Nesselrod[14] explains anal infection on the basis of a chain of events which occur in the pathogenesis of anorectal inflammatory disease. Infectious intestinal material, especially when it is soft or liquid, can easily gain entrance into one or more anal crypts. The tiny, vestigial anal ducts which lead from the bottom of the crypt to rudimentary glandular follicles afford excellent ports of entry. The lymphatics probably play an important role in anal infection. An underlying etiologic factor of which the profession does not seem to be aware is that anal infection provides the first step in the development of the phlebitis which underlies hemorrhoidal disease. It takes part in the development of anal fissure, abscess, fistula and related conditions; that is, these common disorders constitute various manifestations of anal infection. Any therapeutic procedure which ignores anal infection is likely to fail as far as the cure of anorectal inflammatory disease is concerned. (Nesselrod)

Papillitis.—The anal papillae may become enlarged and inflamed and cause considerable discomfort from pain and irrigation. The treatment is injection of 0.125 per cent eucaine solution (Gant) and crushing the papillae or destroying them by fulguration. They may also be excised or ligated at the base.

Proctitis.—Inflammation of the rectum may arise from a wide variety of causes and organisms. It varies in degree and in location and if untreated may bring about most serious results. Gonorrheal infection of the rectum "is a common complication of the genital infection in women."[15] Randall and Jackman[16] report prompt improvement with sulfanilamide therapy in a case of gonorrheal proctitis. A useful treatment probably is irrigations with plain water at 110 F. Martin says: "The patients in my series were treated by rectal instillations of 1 ounce (30 cc.) of 5 per cent mild silver protein twice daily. If anal soreness was prominent, an ointment or suppository containing a local anesthetic was employed. The bowels were regulated. The patients were instructed to instil the mild protein through an 18 or 20 French

soft rubber catheter." According to Gant,[17] "Acute catarrhal proctitis may disappear spontaneously, but treatment is essential in most cases. This class of patients recover more quickly when put to bed, restricted to a diet composed of soups, broths, gruel, soft-boiled eggs, or scraped meat, and the rectum is cleared of food remnants, hardened feces, mucus, and irritating discharges by normal saline or boric acid irrigations, or an enema following a dose of mineral water or sulphate of magnesia or soda. The rectum is cleansed twice daily with an antiseptic or astringent irrigant, the strength of which is increased when erosions or ulcers are numerous or large; silver nitrate, 1:3000; thymol, 2; potassium permanganate, 1; boric acid, 5; carbolic acid, ½; hydrastis, nonalcoholic, 1; argyrol, 6, or ichthyol, 2 per cent," using a return-flow irrigator. For rectal irrigations the "recurrent rectal tube" of Bassler[18] is useful.

Cryptitis.—This condition is an inflammation of anal pockets, Morgagni's crypts. It is accompanied by pain and itching. The pockets are exposed by a speculum and irrigated with warm water and swabbed with pure ichthyol. A nutgall and stramonium ointment administered through a "pile pipe" is

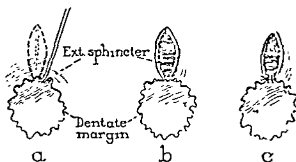


Fig 246.—Cryptectomy. *a*, Probe in place for incision. Dotted line indicates additional excision of skin. *b*, Excision completed. *c*, Sutures placed to control bleeding or retraction of mucosa. (Smith, N. D.: S. Clin. North America 25: 969, 1945.)

often useful. Surgical treatment is often necessary. Smith[19] says: "The incision is made (usually over a probe) from the orifice of the crypt to a point beyond the anal verge (Fig. 246, *a*) and the margins of this incision are then usually trimmed so as to provide free drainage (Fig. 246, *b*). The relationship of skin and mucous membrane (Fig. 246, *b*) is not altered appreciably. The wound is not sutured closed. Muscle fibers are not incised and they form the base of the wound. Sometimes because of bleeding or retraction of the mucous membrane from the level of the dentate margin it is necessary to place one or two sutures (Fig. 246, *c*)."

Sphincteralgia (Spasm of the External Sphincter).—In this condition there are sudden, involuntary, painful contractions of the sphincter. It is caused by an irritant or a lesion in the vicinity of the anus. The treatment includes *morphine* and atropine hypodermically, hot sitz baths or hot water bags to the anus. Gant recommends the following ointment to be used through a metal pile ointment applicator immediately after defecation:

[illegible]	gr. viij	0.53 Gm.
[illegible]	gr. x	0.6 Gm.
[illegible]	ounce j	31.0 Gm.

The sphincteralgia will not be cured, however, until the underlying cause has been removed. Foreign bodies, fecal accumulation and irritating discharges should be removed. Fissures, ulcers, hemorrhoids, etc., should be remedied. In many cases relief can be obtained by digital dilation of the sphincter.

Fissure-in-Ano.—In this condition there is a longitudinal crack or fissure in the skin of the anus. Not infrequently at the border of the anus at the outer end of the fissure a "sentinel pile" develops. The fissure is extremely painful and at times very difficult to heal. It causes a reflex spasm of the sphincter ani muscle, which in turn interferes with the fissure, thus completing a vicious circle. *Cauterization of these fissures with silver nitrate and other* agents is generally unsuccessful. Lindsey[20] has had successful results from *topical application of 2 per cent nupercaine ointment.* He says that he used *this method (which did not originate with him)* "extensively overseas with uniformly good results. It made the difference between evacuating a man for surgery and allowing him to fight with a painless and healing fissure. Application by the patient for two or three days will do the job." The treatment of choice is excision of the entire fissure under local or general anesthesia.

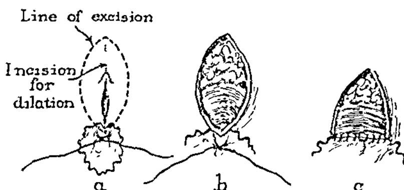


Fig. 247.—Excision of anal fissure *a,* Suture placed in normal mucous membrane above the dentate margin. *b,* Excision of fissure completed. *c,* Completion of suturing at level of dentate margin. (Smith, N. D : S Clin North America 25: 969, 1945.)

Smith[19] says: "Frequently an anal fissure is complicated by the presence of an enlarged papilla and an external tag; often there is also a small subcutaneous abscess or a tiny superficial sinus resulting from the surgical or spontaneous drainage of a preceding abscess. Frequently also the anus is contracted, necessitating dilatation. Logically the anus should be gently dilated first and then the fissure excised; occasionally it is necessary to incise [illegible] to accom-

[illegible] p the rectal mucous membrane in the anterior or posterior midline about 0.5 cm. above the dentate margin Just above (cephalad to) this clamp place a double tie of plain no. 1 catgut, having the ends each 10 to 12 inches (25 to 30 cm.) long. Starting between the clamp and the double-tied suture a curved incision may be made on either side of the fissure in normal anorectal tissue, mucous membrane and skin, superficial to the external sphincter muscle and extending in the quadrant involved about 2 5 cm. beyond the anal margin (Fig. 247, *a*). It may be necessary to dissect the base of the anal fissure carefully from the underlying muscle fibers. It is not possible always to avoid the muscle fibers entirely but a slight defect in the surface of muscle is not of great moment Contrary to the advice frequently given, it is not [illegible] When the

"The double-tied suture (Fig. 247, *b*) may be drawn externally toward the inner margin of the external sphincter, which is usually thinner posteriorly than anteriorly or laterally. The tied suture marks that portion of the mucous membrane which should be placed in the midline. A curved, saber-pointed needle should be placed on one of the long ends of the suture and the cut edge of the mucous membrane should then be sutured to the cephalad margin of the external sphincter muscle; beginning medially the suturing should extend laterally to the junction of the skin and mucous membrane. A continuous locked suture is very satisfactory and the needle should be introduced about 0.3 to 0.5 cm. above the cut edge of the mucous membrane; it should then be brought out just at the cut edge of the mucous membrane and reintroduced into the muscle as mentioned previously. The bite of muscle tissue should be sufficient to insure the stability of the relationship of muscle and mucous membrane as the needle and suture are pulled through the muscle and the suture is locked before repeating the next and more lateral suture about 0.3 cm. distant. After suturing the left half the right half may be treated similarly (Fig. 247, *c*). If there is an internal or external hemorrhoid on either side of the fissure it may be removed and the suture extended to include this wound too.

"When the wound is completed the area of that portion of the wound outside the anal margin should be greater than that portion of the wound between the dentate margin and the anal margin. Careful examination of the muscle fibers forming the base of the wound occasionally may reveal some fibers projecting above the level of the others. These fibers should be incised in the midline, since this will insure satisfactory drainage. A gutta-percha drain and a small gauze sponge saturated with white petrolatum inserted through the anus, the latter in contact with the denuded surface, will provide a satisfactory dressing."

Anal Fistula (Fistula-in-Ano) and Perianal Abscesses.*—"The Latin word fistula means pipe; and a piece of pipe has two openings—one at either end. Accordingly, therefore, the term 'blind internal fistula' or 'blind external fistula' as applied to a tract which ends blindly is a misnomer; the proper term in this instance being 'sinus.' Practically all anal fistulas originate in an anal crypt—hence the term fistula-in-ano.

"There seems to exist considerable misunderstanding with regard to anal fistulas and to abscesses which occur in the tissues surrounding the anal canal and rectum. A thorough understanding of the pathogenesis of anal fistulas will simplify the problem and will facilitate treatment. Abscess formation is a definite step in the establishment of fistula-in-ano, hence the very logical reason for describing abscesses under the heading of fistula-in-ano.[22]

"Stage I: Infectious material invades the anal crypt and the tiny, vestigial anal ducts attached thereto.

"Stage II: The infection is carried into the surrounding tissues via the lymphatics.

"Stage III: The infected tissue (usually loose, fatty areolar tissue) breaks down into an abscess, the signs and symptoms of which are familiar to every physician—redness, local heat, swelling, tenderness and pain. It is usually at this stage that the patient first seeks medical aid.

"Stage IV: The abscess ruptures spontaneously or is incised. Not until drainage has been established can the term 'fistula' be properly applied. One opening of the fistula, namely, the infected crypt, is provided in stage I. The other opening occurs in stage IV.

"Buie has logically termed the infected crypt the 'primary opening' of the fistula. The other opening (single or multiple) is therefore called 'secondary,' whether it occurs in the rectal wall above the dentate margin or in the skin about the anus or over the buttock.[23]

* This section was written by Dr. J. Peerman Nesselrod for Christopher, F.: Textbook of Surgery, ed. 4, Philadelphia, W. B. Saunders Co., 1945, p. 1087, and is reproduced with Dr. Nesselrod's permission.

"Now that the role played by an abscess (stage III) in the formation of an anal fistula has been discussed, the various locations involved by abscess formation may be considered. There are no true spaces about the anal canal and rectum; hence one speaks of 'surgical spaces' as spaces which can be created by dissection or by dissolution of tissue during the infectious process resulting in an abscess. There are five such spaces: the two ischioanal spaces or fossae beneath the levator ani muscles (Fig. 248, a, *I.A.*), the two pelvirectal spaces (Fig. 248, a, *P.R.*) and the retrorectal space above the levators (Fig. 248, b and c). When one or both ischioanal fossae are involved, the signs and symptoms are obvious to both the patient and the physician, as previously described, because of the superficial location of the abscess inferior to the pelvic diaphragm. However, involvement of any of the three deep spaces above the pelvic diaphragm is accompanied only by vague symptoms—a feeling of weight or heaviness in the pelvis and possibly chills and fever.

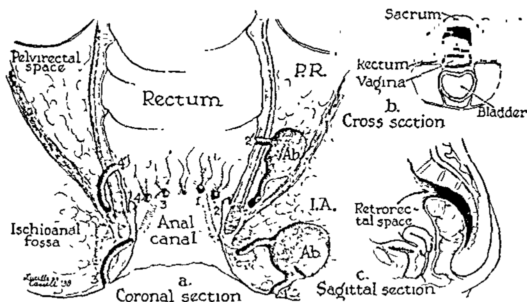


Fig. 248.—A diagrammatic representation of anal fistulas and of surgical spaces (see text). *P.R.* indicates pelvirectal space; *I.A.*, ischioanal space or fossa; *Ab.*, abscess; *1, 2, 3, 4,* fistulous tracts; *1', 2', 3', 4'*, secondary openings.

The diagnosis depends upon careful digital palpation, which will disclose a 'doughy' swelling encroaching on the rectal lumen. Batson has pointed out that the ischioanal fossa can hold no more than 2 or 3 ounces of fluid even under pressure, because the boundaries of this cavity are fairly rigid. He calls attention further to the fact that the roof of the pelvirectal space is peritoneum, which is capable of being floated upward. Accordingly, therefore, when an ischioanal abscess is incised and a great deal more than 2 or 3 ounces of pus is obtained, one can be reasonably certain that the infectious process has involved a 'deep' space (above the levators) as well as a superficial one. Communications between the superficial and the deep spaces occur usually near the anal attachments of the levator muscles.

"In figure 248, a, the tract labeled 1 leads to an abscess (*Ab.*) in the ischioanal fossa. Drainage is established by the secondary opening 1'. Tract 2 originates at the usual level in an infected crypt but leads to an abscess (*Ab.*) above the levator in the pelvirectal space on that side. The abscess has rup-

tured into the rectum at 2′, which is the secondary opening of the fistula. Tracts *3* and *4* represent diagrammatically the appearance after contraction of the abscess cavities. Hence the primary openings lie in the anal crypts at the level of the dentate margin. Openings at any other place, either on the skin surface or in the rectal wall, are secondary—and the term fistula-in-ano still holds, because the primary source of the fistula in either case is a crypt, which is an anal structure.

"An acute abscess requires drainage. The choice of a point of incision is important. If fluctuation is present, an incision should be made at that point, but the opening should be made as near the anus as possible in order that the resulting fistulous tract may be as short as possible. In the case of a deep abscess, with or without involvement of the ischioanal fossa, drainage should be established through the ischioanal fossa of the involved side rather than through the rectal wall. In the case of a retrorectal abscess, drainage can be established through the anococcygeal raphe or to either side of it and as near the anus as possible. The author then usually waits for ten or fourteen days before performing fistulectomy.

"The treatment of anal fistula is the same regardless of etiology, namely, complete exposure of the tract from primary to secondary openings, with excision of the overhanging edges so as to create a flat wound. This can usually be done in one sitting, and all the existing tracts can be laid open at one time, provided, of course, careful attention is given to after-care. An essential feature in fistulectomy is adequate exposure; this is best obtained with either low spinal or sacral block anesthesia. The other types of anesthesia do not permit satisfactory anal relaxation.

"There is one notable exception to the opening statements in the foregoing paragraph, and that pertains to a fistula which is found in a patient suffering from thrombo-ulcerative colitis (chronic ulcerative colitis). It is not wise to undertake anorectal treatment in these cases, because the wound will not heal. It is permissible to drain an abscess, but to do a fistulectomy, a hemorrhoidectomy or a fissure operation for a patient suffering from chronic ulcerative colitis is definitely contraindicated."[24]

Buie[25] writes as follows: "The gauze (usually iodoform) which is placed in the cavity of the wound should not be allowed to remain in position too long. I usually succeed in removing all of the gauze from the largest wounds within four or five days following the operation. The gauze is out of small wounds within seventy-two hours. In this series not one of the entire group had incontinence of soft or solid stools." Weisel and his associates[26] write: "In cases of fever for which no cause can be found, the physician should consider the possibility of a perirectal abscess."

Pruritus Ani.—Intractable itching about the anus is exceedingly annoying to the patient and is extremely difficult, in many instances, to cure.[27] Among the causes are: (*1*) the irritation of even the slight amount of fecal matter not removed by dry toilet paper; (2) ringworm or yeast infections; (3) bacterial infections, such as by the colon bacillus or Streptococcus faecalis; (4) animal parasites, pinworms or other intestinal worms or amebas; (5) local ailments, fissures, hemorrhoids, fistulas, skin tags, anal papillae or spasm of the anal sphincter; (6) intestinal disease, cryptitis, proctitis or colitis; (7) intestinal stasis, causing fermentation, absorption of toxins and irritation of the anus by hard feces; (8) liver disease, cholecystitis, cirrhosis or carcin-

oma; (9) genitourinary disease, nephritis, cystitis, prostatitis, urethritis, vesiculitis or endometritis; (10) anemia, diabetes, exophthalmic goiter, the menopause or pregnancy; (11) neuroses, and (12) eczema or lichen simplex chronicus.[28] Tell Nelson,[29] of Evanston, Ill., has found a number of cases of pruritus ani in which allergy has played a part. Definite improvement followed the exclusion of the particular foods to which each patient was found to be allergic. Small ulcers of the anal canal should be anesthetized with procaine and cauterized by the actual galvanocautery. Thorough cleanliness is obtained by washing with soap and water on absorbent cotton, especially after defecation. Granet[30] obtained good to excellent results in 93 per cent of 80 cases of pruritus ani by a routine of treatment directed toward preventing fecal perianal soiling. Hill[31] has recommended several applications, including the following:

(1)	Phenol	gr.xv
	Zinci oxidi	drachm j
	Ung. aquae rosae	ounces ij
or		
(2)	Crude coal-tar	drachm ss
	Zinci oxidi	drachm j
	Petrolati	ounce j

Roentgen treatment is frequently of definite value but should not be used unless all pathologic features, such as hemorrhoids, fissures and fistulas, have been surgically removed and the absence of yeast or ringworm infections has been demonstrated. Six to eight weekly treatments of unfiltered *x*-rays in a dosage of 75 to 80 r at each treatment give relief in many cases. The treatments should be given with great care so as to avoid *x*-ray burns. Should improvement not occur in this time, the treatment should be discontinued.[32] It is not unusual to have this condition associated with hemorrhoids, in which case the hemorrhoids will be excised.

The technic of subcutaneous injection of alcohol for pruritus ani is described by Haskell and Smith[33] as follows:

"The patient is placed in the Sims position and the perianal area is prepared as for any rectal operation under local anesthesia. Only a segment of perianal skin, either one fourth [illegible] d a 2 per cent solution of [illegible] of fluid as possible being [illegible] nd without withdrawal of the needle, the fan-shaped segment selected is injected from the border of normal skin to the mucocutaneous margin. From 3 to 5 cc. of procaine hydrochloride solution is required and it is advisable to inject it under an area slightly greater than that in which the alcohol is placed. The needle is next carried near the outer limits of the anesthetized area, a second syringe is attached and 70 per cent ethyl alcohol is injected as the needle is withdrawn [illegible] chloride has been properly placed, very little discomfort is experienced. The patient is advised to carry out adequate cleansing of the area, to apply hot saline compresses two or three times daily for several days and to keep a suitable dressing over the area. The same procedure is then repeated at intervals of from four to seven days until the entire perianal

. . .. one time, from four to six
n 15 to 20 cc. of alcohol.
his plan of treatment. The
alcohol must be placed in the relatively loose subcutaneous tissue. If it is injected intradermally, a slough is certain to result. Care must be taken also to avoid injecting it deep enough to involve the anal sphincters. In the male, the membranous urethra is not far beneath the skin, and the alcohol must be placed superficial to this structure to avoid serious injury. Too great a quantity should not be injected under a small area. This is especially likely to occur under the creased skin between the folds. Excision of tissue is not to be done at the same time as the injection, or an indolent wound will result which may require weeks to heal." Buie[34] uses the fingers to spread the anal folds when injecting alcohol (Fig. 249).

Manheim and Marks[35] report as follows: "Eucupin dihydrochloride 0.1 per cent, with procaine hydrochloride 1.0 per cent, in saline has been found a very reliable anesthetic for

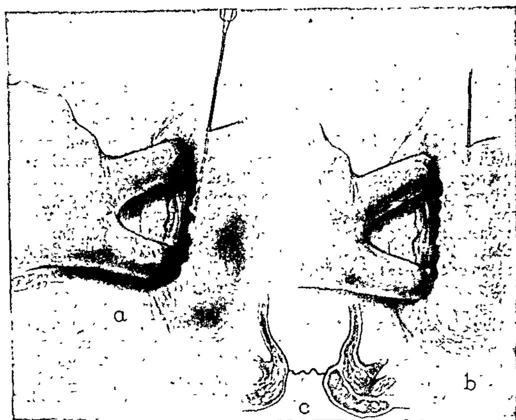


Fig. 249.—*a* and *b*, Injection of alcohol. Solution injected as fingers spread anal folds; *c*, solution between skin and muscles and not injected into either. (Buie, L. A.: Practical Proctology, Philadelphia, W. B. Saunders Co., 1937.)

minor rectal surgical procedures *Anesthesia is rapid, and is not attended by tissue reactions,* irritations, or evidence of any systemic effects." They add that "eucupin in oil, like other anesthetics of this type, requires a special technique in its use to avoid pooling. The formula has been employed successfully in a variety of anal conditions both for treatment, and for surgical repair.

"Its greatest value, we believe, is in the treatment of pruritus ani, as the infiltration may be repeated a number of times, as the condition demands. The analgesic effect of a single injection usually persists from two to six weeks, and when the substance is properly used, local tissue reactions are rare "

Lieberman[36] says: "In a series of 30 cases of pruritus ani based on various pathology in which I have employed injections containing nupercaine 0.5 per cent with phenol 1 per cent, and benzyl alcohol 10 per cent in almond oil, 28 had relief varying from a complete cessation to marked improvement of the itching. This relief is still present after six months."

Lilienthal[37] describes the following simple treatment for pruritus ani:

"The parts should be thoroughly cleansed with any of the noninflammable grease solvents. Next the patient should hold the buttocks apart so as to expose the region to the air until it is perfectly dry. It is usually unnecessary ever to repeat this first cleansing process. The [illegible] will then remove the feces, which will not have come in contact with the skin. After a few weeks of this treatment without the recurrence of pruritus, one may assume that healing has taken place, and the prevention of soiling the sensitive skin will avoid recurrence. For this purpose the use of the zinc ointment may be continued or, better, 25 per cent Burow's solution (solution of aluminum acetate) in a suitable ointment base. For convenience the ointment used should be provided in collapsible tubes. There is of course no objection to the occasional cleansing of the parts with soap and water so as to get rid of the ointment, say about once a week. I have had many years of experience with this form of treatment in numerous cases, with almost uniform success. Everything depends on the patient's intelligent cooperation."

Hollander[38] tattooed with mercuric sulfide the perianal skin of 15 patients for severe chronic anal pruritus. This resulted in relief of the itching and the return of the skin to a normal texture. Two patients have remained well for more than one year, 3 for more than six months and 10 for less than six months. Turell[39] has had favorable experience in tattooing with mercuric sulfide in 37 cases. At present he tattoos not only those patients with intractable pruritus ani of long standing who failed to respond to established therapeutic measures but also patients who have pruritus ani that is recalcitrant to treatment regardless of the duration of the lesion and the few so-called psychoneurotic patients with cutaneous perianal changes consistent with pruritus ani. Selection of patients is important, as results show that tattooing with mercuric sulfide is apparently ineffective for pruritus that is primary in the perineum and posterior vulva but effective in those cases in which there was a spread of the pruritus from the posterior to the anterior perianal areas involving the perineum and the posterior portion of the vulva. The treatment has thus far proved of little value for pruritus vulvae either of undetermined origin or with superimposed dermatitis.[40] Archlike and circular incisions with and without suture have been advised. Even undermined radial incisions have been employed.[41] Operations upon the sympathetic system have been described.

Gabriel[42] recommends the injection of a mixture of anesthesin, 3 per cent; benzyl alcohol, 5 per cent, and ether, 10 per cent, in sterilized oil in the treatment of pruritus ani. At the first injection 10 cc. is given. "This amount is injected in relation to the posterior half of the perianal region through four punctures, 2.5 cc. being injected at each point indicated." Five cubic centimeters may be injected each of the two succeeding weeks In one case Wharton[43] had success with the local application of stilbestrol in oil. He has also used a colloidal astringent called negatan.[44]

Tuberculosis of the Anal Canal and Rectum.—Petter and Fansler[45] have furnished a very interesting discussion of tuberculosis of the anus and rectum. They classify these lesions as follows:

(*A*) *Perianal Cutaneous Tuberculosis.*—(*a*) Miliary tuberculosis of the anal skin. This occurs in conjunction with acute general miliary tuberculosis, which is highly virulent and rapidly fatal.

(*b*) Tuberculosis cutis orificialis This occurs in the mucous membrane and adjacent skin of patients who have little or no resistance to tuberculosis.

(c) Lupoid cutaneous tuberculosis. This occurs as a subcutaneous nodule covered by healthy but slightly bluish skin and is seen in patients who have a manifest resistance to tuberculosis. "This lesion is diagnosed on biopsy. In some cases it may go on to central necrosis with resulting ulcer formation. Surgical removal or destruction with actual cautery, followed by ultraviolet radiation, gives very satisfactory results."

(d) Tuberculous anal ulcer. This is a ragged, indurated, fiery red ulcer which develops at the site of a previous simple fissure in patients with a positive sputum test or an active intestinal lesion. Petter and Fansler find "the best treatment for these lesions to be section of the external sphincter, followed by destruction of the diseased tissue with the cautery. Daily applications of heat and ultraviolet irradiation hasten healing of the operative wounds."[46]

(B) *Perirectal Abscess and Fistula-in-Ano.*—The diagnosis and treatment of these lesions has already been given. Petter and Fansler say that "the 'proof of tuberculosis' is often quite a task. Smears of exudate are not reliable nor are guinea-pigs inoculated with the [illegible]

picture of chronic inflammation, but no tubercle formation, and a piece of the same tissue macerated or suspended in normal saline and injected into a guinea-pig will show definite evidence of tuberculosis.

"When should one treat a fistula or abscess surgically, in the tuberculous patient? Cer- [illegible]

cleaning up a lesion surgically, the body is relieved of one extra focus of disease, and general improvement in the majority of patients so treated is noted.

TUMORS

Rectal Polyps (Adenomas).—These polyps are benign pedunculated or sessile tumors arising from the rectal mucosa. According to David, their attachment is always at the mucocutaneous line. They may attain the size of a small egg and be quite firm in consistency. They may be multiple and are most commonly encountered in patients who are young. In Smith's[47] patient, a child of 6 months, the polyps measured 5 by 4 by 4 cm. Bessesen[48] reported a case of rectal adenomatous polyp with carcinomatous degeneration. Their propensity toward hemorrhage is the principal indication for surgical treatment. With the aid of a proctoscope or a rectal speculum these rectal polyps may be cut across at the base and the bleeding point ligated or removed with a clamp and cautery. Caylor[49] reports the case of a woman aged 54 from whom a fibromyoma of the rectum weighing 110 Gm. was successfully removed.

Adenomas originating from the rectal mucosa may attain the size of a walnut. They are pedunculated tumors which may arise at any point on the rectal mucosa. They are usually accompanied by bleeding and may protrude from the anus. They generally may be drawn down and removed by clamp and cautery. Those higher up in the rectum may be fulgurated through a speculum. (David) The writer saw a child who had been troubled with chronic rectal hemorrhage in which what was doubtless a rectal adenoma was extruded through the anus in the active stool. The mother of the child, seeing the protruding polyp attached by a small pedicle, grasped it and pulled it off and was then seized with no little concern because of the profuse hemorrhage which resulted. This, however, fortunately subsided spontaneously.

Condylomas.—Condylomas are wartlike rectal excrescences in the region

of the anus and generally are related to venereal disease. Their treatment has been described in the section on tumors of the female genitourinary system.

Knoflach[50] reported 2 cases in which circumscribed *hyperplasia of the lymphatic tissue of the rectum* caused the development of polypus formations. Smith[51] has reported 3 cases of primary lymphoid tumors of the rectum resembling internal hemorrhoids.[52]

Malignant Tumors.—Carcinoma and sarcoma of the rectum belong to the realm of major surgery.

However, everyone should be familiar with the diagnostic features of carcinoma of the rectum. In 26 per cent of all cases diagnosed at the Mayo Clinic, the patients had previously been operated upon elsewhere for hemorrhoids without adequate preliminary rectal examination. Cutting's[53] statement of the symptoms and signs of anal carcinoma is admirable and is given herewith:

"The earlier symptoms and signs are often vague, and never pathognomonic. They depend upon (*a*) ulcerations, (*b*) stenosis, and (*c*) tumor formation. They consist of (1) Changes in *previous bowel habits, especially constipation, and when present, 'morning diarrhea'*; (2) a sense of discomfort in the rectum not relieved by defecation; (3) pain, usually noted rather early in the anal carcinoma, infrequently and late in the ampullary and rectosigmoid types; (4) bleeding which may be inconsiderate in amount and consequently overlooked, but 'all rectal cancers bleed' (Rosser).

"*In the intermediate stages the symptoms and signs are similar but more pronounced:*

"1. Constipation or alternating constipation and diarrhea.

"2. Increasing local discomfort.

"3. Moderate pain depending especially, as just previously noted, upon the type of carcinoma.

"4. *The discharge of blood, either alone or in combination with mucus or pus,* and

"5. Moderate loss of weight.

"Rankin, reporting the Mayo Clinic statistics, in an unclassified grouping of cases, for the ten-year period ending January 1, 1916, which were based on 602 cases of rectal carcinoma, gives the percentage of incidence of the cardinal symptoms as:

"1. *Rectal bleeding 89.5 per cent of cases.*

"2. Constipation 55 per cent.

"3. Diarrhea 20 per cent.

"The classical text-book symptomatology of rectal carcinoma as given in the older literature, which includes anemia, cachexia, 'ribbon-stools,' and the symptom-complex characteristic of low intestinal obstruction, represents a terminal stage of the disease, which should never be allowed to develop in the presence of modern methods of diagnosis and treatment."[54]

CONGENITAL AND ACQUIRED DEFORMITIES

Imperforate Anus.—Imperforate anus is that condition in which the infant is born with skin completely blocking the anus, or a short distance up the anal canal, so that there is no opening whatsoever. This affliction will require prompt surgical treatment. Without any anesthesia whatsoever an incision is made into the obstructing membrane, and the wound is dilated with the finger. If there is atresia of the rectum, the surgeon should be prepared to dissect the perineum until the rectum is encountered, or to do a colostomy if necessary.[55]

Anorectal Stricture.—Stricture of the anus and lower part of the rectum may be congenital or acquired. *In congenital cases the opening may be* extremely small. Brennemann[56] has reported 6 cases of "infantile congenital [illegible] of the simple diaphragmatic type, in which [illegible] ptom. The obstruction [illegible] strictures are due to

inflammation.[57] The treatment of anorectal stricture is careful and gradual dilation of the stricture. This will be done with well lubricated bougies, extreme care being taken not to puncture the rectal wall beyond the stricture. When possible these dilations should be done daily, and the patient's mother, if possible, will continue the dilation digitally. The gloved and lubricated little finger will first be inserted into the rectum and succeeding fingers used, until finally the thumb is used. Beyond this size and in some cases in the absence of digital dilation, hard rubber rectal dilators will be used. After the dilator is passed it will be left in place for a few minutes before withdrawal. The congenital strictures may be "cut longitudinally and, after mobilization of the mucosa, sutured transversely." (David)

In anorectal lymphogranuloma venereum, the sulfonamides and inactivated virus should be used, according to Grace.[58] He says: "Surgery has a place in the treatment of many of the manifestations of anorectal lymphogranuloma. It should, however, be preceded and followed by at least one course of sulfathiazole therapy. Fibrous stricture is uninfluenced by any form of treatment; in the absence of proctitis, the lumen of the strictured area may be enlarged by the use of dilators." Colostomy or abdominoperineal resection of the rectum may be necessary.[59] Martz and Foote[60] have had success with diathermy in the treatment of stricture of the rectum secondary to lymphogranuloma venereum.

Incontinence of Feces.—This condition may be due either to local injury of the sphincter or to disease or injury of the central nervous system. The treatment, if any, will be major surgical.

Prolapse of the Rectum (Procidentia Ani; Procidentia Recti).—In this condition there is abnormal descent of a portion of the rectal mucosa or the upper portion of the rectum into the lower portion of the rectum or through the anus. In cases of partial prolapse, only the mucous membrane descends; in cases of complete prolapse, all the walls of the bowel are involved. This condition occurs more frequently in infancy and childhood but may occur at any age. It may be an accompaniment of any condition in which there are frequent evacuations, coughing or straining. In young children having prolapse of short standing a cure often may be obtained by nonoperative means. Gant[61] says that he has succeeded in permanently curing procidentia ani in children under 5 years by "(*a*) prescribing a daily laxative or enema to prevent constipated stools and straining; (*b*) circumcising the child if troubled with phimosis; (*c*) administering soothing medicines to allay coughing and antidiarrheal remedies to diminish frequency and fluidity of the evacuations; (*d*) irrigating the rectum morning and night with a cold infusion of quassia, black oak bark, or solution of ichthyol, balsam of Peru, or alum solution, 20 grains to the pint, to tone and pucker up the mucosa; (*e*) replacing the bowel after stool; (*f*) having the patient defecate in the recumbent posture or on the side, with the hips elevated, to diminish pressure upon the lower rectum, and (*g*) constantly keeping a pyramidal-shaped compress over the anus, held in place by a T-binder or strong adhesive straps, that pull the buttock over it, thus preventing the child from straining down, and which stimulates sphincteric contraction, and strengthens the anal outlet" (Fig. 250). The treatment must be carried out for weeks or months.

In recent cases in which the bowel is merely edematous and has not become ulcerated or gangrenous, the physician will attempt to reduce the prolapse

manually. "In exceptional cases general anesthesia or infiltration of the sphincter with eucaine, and stretching or dividing the muscle, is required to release the strangulated bowel. With one or two exceptions the author (Gant) never has failed to reduce prolapse in the following manner: With patient in the knee-chest posture, extruded gut is cleansed with warm boric acid, and covered with soft linen or silk smeared with oil or vaseline, then the tumor is grasped in the hollow of the hand and squeezed free of serum by even pressure made on all sides, after which the protrusion is gradually replaced by beginning at its distal extremity and working the extruded gut upward and through the sphincter with the fingers separately manipulated." (See Gant, *loc. cit.*) Rectal plugs and pessaries are sometimes of use in adults. Various surgical procedures have been advised. In the Gant local anesthesia

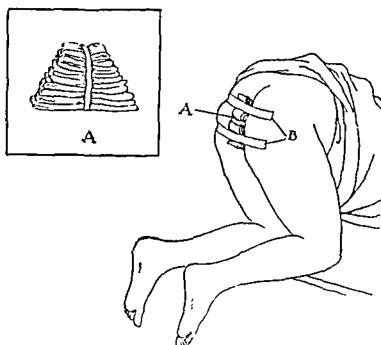


Fig. 250.—Gant's method of preventing and curing procidentia ani by supporting the anus with (*A*) a pyramidal compress and (*B*) firmly strapping the buttocks over it. (Gant, S. G.: Diseases of the Rectum, Anus and Colon, Philadelphia, W. B. Saunders Co., 1923.)

ligature operation, various portions of the everted mucosa are ligated in little bunches under local anesthesia. The extruded bowel is then reduced. With the healing of the ligated portions, the cicatrices which result will take the slack out of the mucosa. A purse string encircling the anus or the excision of a circular strip of mucous membrane has been used. An operation similar to the Whitehead operation for hemorrhoids also has been employed.

Eliason and Erb[62] report 3 instances of cure of rectal prolapse by strangulation of the prolapse with an elastic ligature after a $\frac{3}{4}$ inch rubber tube had been replaced in the rectum.

in small children has rendered practically

inflammation

followed by proliferation of connective tissue in the space between the rectum and the lower pelvic floor." The prolapse is first reduced by steady pressure after lubrication with olive oil and is held in place by strapping the buttocks together. The patient is given a mild purge and a cleansing enema before operation. Ether is preferable in small children. For a 3 year-old child Klopp describes his technic as follows:

The patient "is held in the lithotomy position while I cleanse the field with soap, water, and alcohol, and drape him. Now, using my left index finger in his rectum as a guide, I take this syringe containing 2 cc. of absolute alcohol in the other hand and, using a long *needle of about 23 gauge, inject it perirectally. Notice that I insert the needle at right angles*

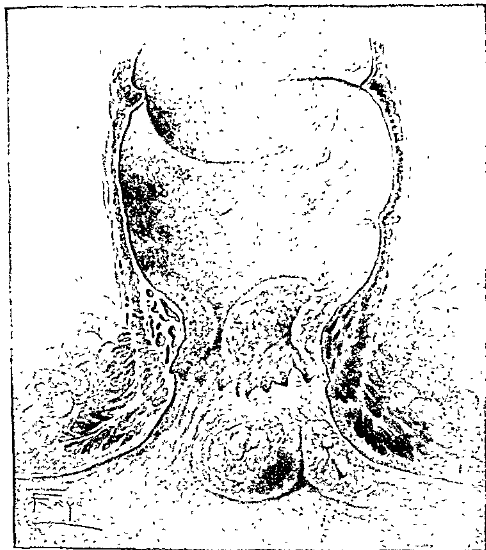


Fig 251.—Lo[illegible] through the [illegible] rectum, [illegible] positions of the [illegible] (B[illegible], L. A.: Proctoscopic E[illegible] P[illegible]delphia, W. B. Saunders Co , 1931.)

to the skin about 0 5 cm. to the left of the anal margin at a point just posterior to its horizontal diameter. In a child of this size the alcohol is injected at a depth of about 4 cm. Care must be exercised not to get too close to the rectal wall with the point of the needle, for infection might result. Two cc. are injected in a similar manner on the left side, but before doing this, I will first change my gloves and use the right index finger as a guide in the

The wound heals by granulation. This treatment may be carried out at home or in the office; generally it will completely cure this particular hemorrhoid and will afford the patient almost immediate relief. Hill[68] prefers infiltrating the entire thrombosed hemorrhoid, excision of an elliptical portion of the skin and the dissecting out of the clot, capsule and overlying skin *en masse*. Catgut sutures are employed, if necessary, to close the incision. If other piles are present or the thrombosed pile is particularly large, a regular hemorrhoidal operation may be necessary.

While most authorities subscribe to the evacuation treatment of the thrombosed pile, Smith[69] sounds a note of warning in the treatment of acutely strangulated piles or, in other words, multiple thrombosis of the superior hemorrhoidal veins. When this is a large mass outside the anus which is sloughing and discharging freely and is early accompanied by a great deal of pain, Smith advises putting the patient at absolute rest in bed upon a restricted diet. "A wet compress of boric acid solution, either hot or at room temperature, is comforting to the patient and assists in promoting absorption of the clots. If the pain be great, morphine may be used either hypodermically or by mouth. Opium suppositories are contraindicated here or at any other time. Opium has no local action and may be irritating in a suppository.

"Sloughing may go on to a spontaneous cure of the hemorrhoids. If this should not occur, the hemorrhoids may be taken off by any appropriate operation, or they may be treated by the injection of 5 per cent quinine and urea hydrochloride solution after the clots have been absorbed and fibrosis has occurred, and when all acute symptoms have subsided, which period is usually not under three weeks from the onset of the acute disease.

"If operation be resorted to in the acute stage, a stormy convalescence may be looked for, providing the operator is fortunate enough not to have a more serious result." (Smith)

The diagnosis of internal hemorrhoids will, of course, not be possible from external inspection unless they are prolapsed through the anus. If the anal orifice is everted and the patient is requested to bear down as if going to stool, the internal hemorrhoids may be brought into view. Moreover, palpation with the gloved finger generally will not appreciate the soft, compressible internal piles. The patient, however, will give a history of pain with and without defecation, of bleeding particularly at time of defecation (bright red blood) and occasionally of protrusion through the anus of the internal hemorrhoid. He may say that he has been compelled to replace an internal hemorrhoid digitally. Proctoscopic examination of the lower part of the rectum will reveal the internal hemorrhoids, but this procedure generally is unnecessary in order to make a diagnosis. Patients with internal hemorrhoids are very often well treated without operation. Very careful regulation of the diet, strict cleanliness of the external parts and the use of astringent ointments will greatly relieve or cure the condition. These astringent ointments are numerous and contain a wide variety of drugs. Useful ones are those which contain stramonium and nutgall, ichthyol, minute quantities of phenol or even novocain. These ointments are instilled into the rectum by means of a "pile pipe," which is a fenestrated nozzle which may be screwed upon a collapsible tube. The injection of the ointment is made once or twice daily, particularly after defecation. Another useful measure is the employment of astringent or analgesic suppositories.

The following prescription for an astringent suppository is valuable:

Tannic acid	1.0 Gm.
Balsam of Peru	1.5 Gm.
Bismuth subnitrate	10 0 Gm.
Cacao butter	17.0 Gm.
Cerate	2.0 Gm.

Mix and divide into ten suppositories. Label: one three times a day.[70]

Hill[31] recommends "injection of 1 ounce of olive oil before retiring" as one of the best palliative measures for internal piles. Hot sitz baths are always welcomed by the patient.

The more marked external and internal hemorrhoids will require operation. A wide variety of operations have been devised for the removal of hemorrhoids, but the principles involved are similar in all. These consist of sterilization of the operative field as far as is possible, the removal of the hemorrhoidal mass, the control of hemorrhage and the proper after-care. In the hands of many surgeons, hemorrhoidectomy is a relatively simple procedure. Local anesthesia may be used to advantage. General anesthesia, if elected, will have to be deep in order to secure relaxation. Of recent years caudal sacral anesthesia and low spinal anesthesia have been used and recommended. The patient is carefully shaved and a cleansing enema, preferably of some 8 ounces of boric acid solution, is given before the operation. Preoperative laxatives are contraindicated except when a Whitehead operation is contemplated or when there has been lack of bowel movements for some time. In this case the laxative should be so administered that the lower part of the bowel is thoroughly cleansed on the day before the operation. If one enema fails to do so, it should be repeated. The patient is preferably placed in the prone position with the pelvis well elevated. The buttocks may be separated by an assistant, or, as suggested by Bearse,[71] they may be drawn apart by adhesive strips which fasten to the operating table. If local anesthesia is to be employed, the procedure is carried out as described previously. The sphincter ani will be dilated. This procedure requires a certain amount of patience and skill and should not be trusted to an intern unless he is well acquainted with it. Before starting it, the anesthetist, if a general anesthetic is employed, should be warned that the sphincter is about to be dilated. Dilation of the sphincter ani is a very powerful respiratory stimulant, and the excessively deep inspirations which result may occasion the inhalation of too great a quantity of the general anesthetic agent used. The gloved index finger, which has been well lubricated, is first inserted in the rectum, and the sphincter is stretched in all directions. The index finger of the opposite hand is then inserted slowly, and the sphincter is slowly and carefully divulsed. After an appreciable interval of time a third finger is inserted and finally a fourth. Four fingers generally constitute ample dilation. Most authorities believe that if the sphincter is adequately dilated the postoperative pain will be much less.

The technic of hemorrhoidectomy is described by Newton D. Smith[72] as follows:

"The surgical objective is to remove the hemorrhoids and to restore the relationship of the mucous membrane and skin so that when healing is complete, distortion will not result. The fibers of the external sphincter provide an unusual landmark, for if the external hemorrhoid is removed so that the

muscle is exposed and forms the base of the wound, the surgeon can be certain that he has removed all of it. Also, if the edge of the wound in the mucosa resulting from the excision of the internal hemorrhoid is drawn outward and sutured circumferentially to the inner fibers of the sphincter, the normal relationship of skin and mucous membrane will be reestablished after healing is complete.

"To remove a comparatively small internal-external hemorrhoid, a 6¼ inch Mayo-Ochsner clamp is placed lateral to the external hemorrhoid, and another similar clamp is placed just medial to the first on the external hemorrhoid; a third clamp then is placed in the normal mucous membrane 0.5 to 1 cm. internal to the internal hemorrhoid (Fig. 253, *a*). All clamps should be placed sufficiently deep so as to permit retraction. The second clamp is

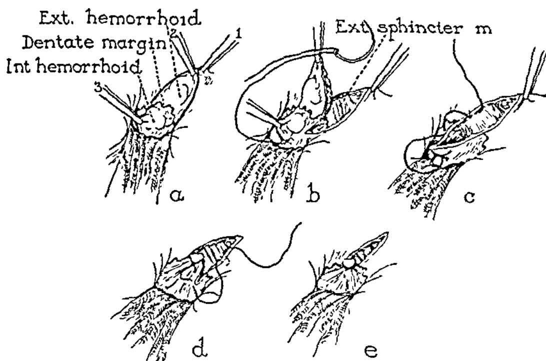


Fig. 253.—Steps in the removal of internal and external hemorrhoids, *a*, clamps, 1, 2 and 3 in place; incision marked; *b*, dissection begun; *c*, dissection completed, half Lembert ... D, ... 15.)

designed to permit manipulation of the hemorrhoid after incision is started. The three gauze sponges are then removed from the anus, and a double tie of No. 1 plain catgut is placed internal to the third or internal clamp (Fig. 253, *b*). The suture is tied so that there is one long end. Dissection is begun laterally between the two clamps on the skin and continued medially to between the clamp and the ligature in the mucosa (Fig. 253, *c*). If, as the dissection is started, the surgeon makes sure that the fibers of the sphincter form the base of the wound that he is producing, then dissection usually progresses easily. After excision is completed, the mucosal stump encircled by the ligature is drawn outward; two half Lembert sutures, one on either side of the stump, are passed first through the mucosa and then through a few of the fibers of the exposed sphincter at the edge of the incision in the skin (Fig.

253, *c*, *d* and *e*); these fix the mucosal stump at the level of the inner fibers of the sphincter. It may be necessary to insert one or two sutures for hemostasis. After one hemorrhoid is removed, three more gauze sponges are inserted into the rectum, and the process is repeated or adjusted to provide for the satisfactory removal of the other hemorrhoids or associated pathologic processes.

"The outlined technic may be varied greatly, especially if the surgeon will notice that an irregularly diamond-shaped wound is produced when the excision is completed. The two medial sides in the mucosa may be retracted and so sutured that the diamond may be altered to produce a triangular-shaped wound, with the elongated base of the triangle formed by the mucosal edge sutured to the internal fibers of the external sphincter. The other two sides of the triangle will be formed by the skin margins of the wound. Several clamps can be used in the mucosa to mark the internal limit of the excision and to provide traction or hemostasis; several more clamps can be used in the skin to provide easy manipulation of larger hemorrhoidal masses. The first double tie can be placed so that the mucosal stump will be posterior to the midpoint of the incision in the mucosa, and the resulting mucosal edge can be sutured to the internal fibers of the external sphincter by means of a continuous locked suture, using the long end of the tied suture. If clamps are used to mark the internal limit of the region to be excised, then before the dissection is started the suture may be placed posterior to the margin of the hemorrhoid sufficiently deep so as to catch the fibers of the external sphincter. The suture is tied with a long end. This procedure will insure more accurate placement and expedite suturing, since this much will be accomplished before bleeding occurs. If clamps are used, dissection may be completed and the mucosal edge retracted and sutured to the internal fibers of the external sphincter by interrupted half Lembert sutures.

"At the time that the mucosal edge is sutured to the sphincter, two factors must be observed closely: 1. The mucosa must not be drawn too far outward, for an ectropion of mucous membrane will result. 2. The mucosal edge must not be sutured to the internal edge of a partially everted external sphincter, for if this is done, then, after normal muscle tone returns, an overhanging edge or shelf will be produced which may cause an abscess during convalescence. Both of these errors can be avoided by close observation. It is important also that sufficient skin is removed to permit ample drainage of the wound." Nesselrod[73] occasionally omits the suture of the mucosa to the muscle.

A very popular operation which may be used instead of ligation consists in clamping the base of the freed hemorrhoid with a crushing hemorrhoidal clamp. The skin and adjacent portions of the anus are then protected by a layer of wet gauze, and the pile which protrudes through the clamp is burned off with the actual cautery. When the clamp is loosened the charred base generally will not bleed, but if it does, the bleeding point should be recauterized or clamped and ligated. As a further preventive of hemorrhage, some surgeons make a running suture over the hemorrhoidal clamp after the pile has been removed by the cautery and when the clamp is removed pull this running suture up snug and tie it. At the completion of the operation a thin strip of vaselin gauze is inserted into the rectum. This acts as a slight hemostatic agent against the small amount of oozing which may occur. Hill and

David prefer to use no gauze at all. A sterile gauze compress is held snugly *in place by a T-binder. Perhaps preferable to the T-binder is the rectal* binder of Montague. This consists of an elastic belt provided with four clasps *to which are attached, with whatever tension is desired,* four tapes holding a cotton pad.

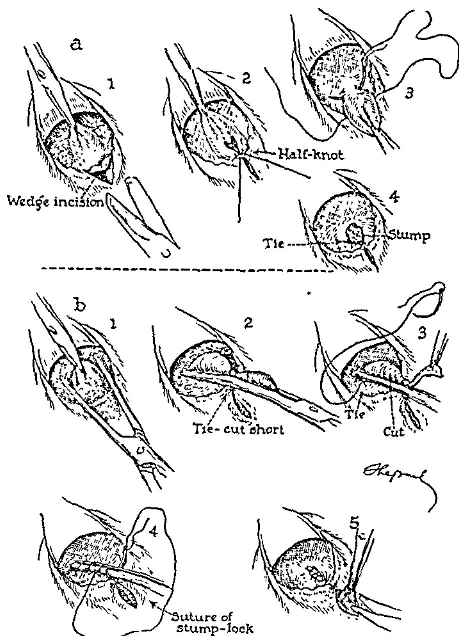


Fig. 254.—Hemorrhoidectomy. *a*, Simple ligation. *b*, Clamp and suture. (Pontius, G. V.: S Clin. North America 23: 255, 1943.)

The simple ligation and the clamp and suture methods of hemorrhoidectomy as described by Pontius[74] are shown in figure 254.[75]

The postoperative care after hemorrhoidectomy is described by Smith[76] as follows:

"The care *of the patient and the wounds after operation are important.* At the completion of the operation, a soft gutta-percha drain 3 or 4 inches

long is inserted into the anus; on both sides of this drain several strips of 2 inch vaseline gauze are placed, which are removed in from eighteen to forty-eight hours. After the patient has returned to his room, his pulse rate should be observed every half hour for eight hours. Morphine sulfate, $\frac{1}{6}$ to $\frac{1}{4}$ grain (0.01 to 0.016 Gm.), is administered hypodermically as required until the acute pain has subsided. As soon as the anesthesia has disappeared, either cold or hot, moist packs may be applied. The postoperative perianal injection of solutions producing prolonged anesthesia frequently causes rather spectacular results, but the method is not free of risk.

"The patient may experience difficulty in voiding, but if assisted, he may be permitted to stand beside his bed or even go to the bathroom. All efforts should be exercised to obtain normal daily stools; the diet may be altered if necessary, but about five to seven days will be required to establish this regulation. After each evacuation, the anus and wounds should be irrigated with warm water (approximately 110° F.), by means of a No. 18 French catheter attached to an enema bag. Hot, moist packs should be applied for from four to six hours daily until most of the soreness has subsided. The patient may be permitted to be up for increasing periods after forty-eight hours has elapsed postoperatively. It is advisable for the patient to stay in the hospital until the sutures have been absorbed or removed. Bleeding tends to occur most frequently from the eighth to the tenth day after operation. The wounds should be closely examined daily for any abnormalities, irrigated with witch hazel and treated with a non-irritating antiseptic, such as an aqueous solution of metaphen. Alert observation to detect complications promptly and to care for each patient's problems sympathetically will be repaid by sincere gratitude and appreciation."

Metamucil or agar-agar, 2 drams three times daily, will be helpful. Daily gentle dilation of the rectum and spreading of the edges of the skin wound are helpful. Zinc peroxide dressing for postoperative anorectal wounds has been praised by Burt and Pulaski.[77]

Benjamin and his associates[78] describe the operation for hemorrhoids ("submucosal morcellation") which they used in 34 cases. A small incision is made lateral to the anus, and through this the hemorrhoid is removed with scissors.

Although the *injection treatment of hemorrhoids* has been in use for over fifty years, recently it has received renewed attention. It is suitable only for uncomplicated internal hemorrhoids.[79] Jackman and Buie[80] studied a series of 47 cases in which there were submucosal nodules in the rectum, 59.5 *per cent* being the result of injection treatment of internal hemorrhoids or rectal prolapse.

Bacon and Wolfe[81] say: "Hemorrhoids of the internal variety when small or of moderate size, and uncomplicated are suitable for the injection treatment. This form of treatment is contraindicated in all *external* hemorrhoids, including skin tags; in the presence of marked fibrosis of the internal hemorrhoids; in complicated cases where inflammation and prolapse are marked, or in those *which* are thrombotic, strangulated or ulcerated; in the presence of associated pathology or a markedly contracted sphincter muscle. [illegible] hemorrhoidal veins.

"The selection of a sclerosing fluid is important in the injection of internal hemorrhoids. Quinine and urea hydrochloride, 5 per cent aqueous solution, and 5 per cent phenol are

standards which may be used with satisfaction. Sodium morrhuate, 5 per cent in benzyl alcohol, may be injected if the patient has an idiosyncrasy to quinine, or during pregnancy when quinine would be contraindicated. A comparative three year study of the effect of solutions of phenol and those of quinine and urea hydrochloride discloses that the results were more satisfactory with the latter, for which reason we employ it routinely.

"The armamentarium necessary for this treatment is a suitable anoscope, syringe, and needle, sclerosing solution, and good light. We use routinely the anoscope designed by C. F. Martin and find it excellent for this purpose. Any type of syringe may be employed for this injection treatment provided it meets the necessary requirements and can be conveniently handled by the operator Either a tuberculin or the ordinary Luer syringe is suitable for this purpose, especially since standard needles can be attached A 24 or 25 gauge needle of medium bevel is preferable. In all cases good illumination is essential whether it be direct or indirect.

"Technic. No preliminary preparation of the patient is necessary. With the patient in the left lateral position, the upper cheek of the buttocks is held by the patient or an assistant and the well lubricated gloved finger inserted into the anus. A few circular movements with the finger before the speculum is introduced, tend not only to moisten thoroughly the anal canal and partially relax the sphincter, but to assist in gaining the confidence of the patient. The speculum is smeared with a water-soluble lubricant and is gently inserted in a rotary manner. Ordinarily this is accomplished more readily if the patient will strain or bear down After the hemorrhoidal tissue is exposed, carefully inspected and the most prominent pile selected for the injection, the surface is wiped clean with a dry cotton applicator and painted with gentian violet 1 per cent solution. The needle is inserted into the upper portion of the pile mass for a distance of approximately ⅛ to ¼ inch. It is important to introduce the tip of the needle into the submucosa and not into the vein. The plunger is slowly pressed until 8 to 12 minims of the quinine and urea hydrochloride solution are injected or until slight ballooning takes place. The surface should appear blanched or ischemic When a sufficient quantity of the solution has been injected, the speculum and needle are withdrawn simultaneously. It is unwise to re-insert the instrument once it has been withdrawn

"There should be no pain at the time of, or following the injection, although a sensation of fullness occurs infrequently. The most common cause of pain is making the injection too close to the anorectal line; so that, should any discomfort take place during the insertion of the needle it should be immediately withdrawn and re-inserted at a higher level. By rotating the speculum, with the tip of the instrument well above this line of junction, the injection can be made painlessly A burning discomfort ofttimes occurs following the injection of too large an amount of the solution

"It is of the utmost importance that the hemorrhoids be treated at regular intervals and not in a haphazard fashion; ordinarily all cases are injected twice weekly without interruption. The number of injections required is determined by the number of hemorrhoids present and their response to treatment It is customary to inject one hemorrhoid at each visit. When they are of small size, however, we do not hesitate to make additional injections, especially if the patient resides at a distance, making frequent visits inconvenient. As an average it may be said that each hemorrhoid requires from two to four injections, so that a total of six to sixteen constitutes a course. Usually at this time the hemorrhoidal masses will have disappeared. Accurate record must be kept as to the site of the injection as well as the amount of solution administered and the date of each injection

"No specific treatment is required following the injection, although the patient is advised *to avoid severe physical strain on the day the treatment is administered*. Liquid petrolatum, ½ to 1 ounce by mouth, is prescribed night and morning during the course of the treatment. A daily evacuation is essential during the course of treatment but drastic purgatives are to be avoided. The regular diet is permitted.

[illegible] diseases.

"The *disadvantage of the treatment is the frequency of* recurrence in from two to five years.

"Complications are comparatively rare in the hands of experienced operators, who care-

fully select their cases for treatment. In some instances a *feeling of syncope may occur* during or immediately after the injection, but such quickly subsides. At times a sensation of heat or slight fullness exists for a few minutes, but rarely does it continue for more than half an hour. Should pain or discomfort occur, the application of compresses wrung out in hot water, or a sitz bath 110 F. are helpful.

"In a small proportion of cases idiosyncrasy to quinine will be noted. This condition may be recognized by the appearance of generalized erythema, urticaria, impairment of vision, pallor, vertigo, deafness or blindness. In such cases, phenol or sodium morrhuate should be substituted in the future.

"Marked bleeding never occurs unless sloughing takes place. In part, this may be avoided by withdrawing the speculum at the same time as the needle. This relieves the tension placed upon the pile mass by the tip of the anoscope and permits the rectal walls to collapse, which serves to exert slight pressure and *thereby prevents bleeding. Sloughing is due to the use* [illegible] on, or to making the injection too [illegible] the instillation of warm olive oil [illegible] quent and pressure with a plug of vaseline gauze, or even ligating, may be necessary.

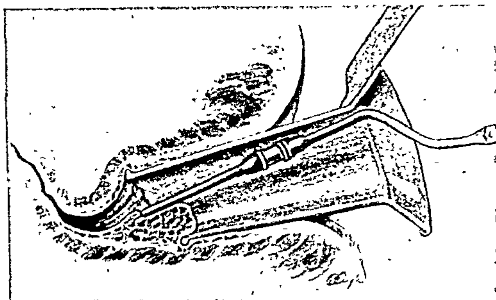


Fig 255.—Sagittal view showing needle in the upper portion of the hemorrhoid, preparatory to injection of the sclerosing solution. (Bacon, H. E., and Wolfe, F. D.: Illinois M. J. 81: 202, 1942.)

"This form of therapy, when instituted by those properly schooled in the anatomy of the anorectal region and in the technic of administering the injection gives excellent and gratifying results. The importance of the proper selection of cases and sclerosing solution used must not be minimized. When the patient has a clear understanding of its value and [illegible]

[illegible] cedure in the treatment of bleeding hemorrhoids, it is in no sense curative and that all patients so treated invariably have a recurrence of the primary condition within a period of a few months. He also says that it is a dangerous method in that it is capable of producing sloughs of the rectum.[83]

Terrell,[84] who introduced quinine and urea hydrochloride as a sclerosing solution for hemorrhoids, has used the injection method in between 4000 and 5000 cases and asserts emphatically that though suitable in only 50 per cent of cases, the method is capable of producing absolute cure.

Kilbourne[85] sent questionnaires to 57 proctologists and obtained the following information: "In 36,648 cases treated by operation there were 11 mortalities and in 26,262 cases treated by injection there were no mortalities that could in any way be attributed to the

injection treatments. Hemorrhage following operation was reported in 0.573 per cent of the cases and following injection in 0 279 per cent of the cases Stricture following operation was estimated at about 0.22 per cent and after injection methods this group of men had practically no strictures at all. Recurrence of the hemorrhoids was much more frequent after the use of injection methods, occurring in at least 15 per cent within three years. Results from the use of phenol in olive and almond oil compared favorably with the results following the use of quinine urea hydrochloride.

Various solutions are employed. The 5 per cent solution of quinine and urea hydrochloride of Terrell is used by Buie,[86] of the Mayo Clinic; 5 to 10 per cent phenol in glycerin, olive oil, cottonseed oil (Goldbacher), Wesson oil or almond oil.[87] Ten to 20 minims of the phenol solution is injected directly into the middle of a selected hemorrhoidal mass. "The amount is not arbitrary, but is gauged by the appearance of the injected area; when the first sign of blanching appears, the injection should be discontinued."[88]

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CHAPTER XVIII

INJURIES OF THE UPPER EXTREMITY*

Contusions, blisters, abrasions and hematomas have been dealt with in the section on wounds, and the rules for their treatment as described there should be carried out. Kanavel[2] and Mason[3] have emphasized how often trivial injuries of the hand lead to prolonged disability and urge great care in all cases.

By the term *blood blister* is meant a small effusion of blood located between the layers of the epidermis. This is at first swollen and painful. It should not be opened but rather should be guarded from traumatism. The swelling will subside and the blood gradually absorb until nothing remains but a

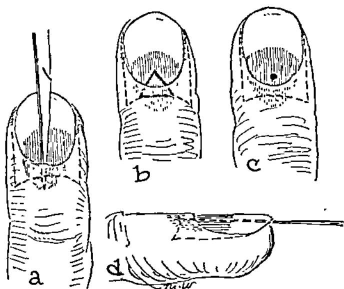


Fig. 256.—Methods of decompression of a subungual hematoma: *a,* A sharp-pointed scalpel lifts the eponychium away from the base of the nail. *b,* A V-shaped piece is excised from the base of the nail. *c,* A small hole is drilled through nail. *d,* A needle is inserted under the nail from the distal end.

small dark-colored plaque. The epidermis overlying this plaque will finally scale off and normal skin will be found underneath.

Contusions of the finger tips are extremely common and will often cause an effusion of blood beneath the finger nail. This is spoken of as a *subungual hematoma.* This condition may be extremely painful. Bakay and Klinko[4] report 10 cases of tetanus in subungual hematomas. In the smaller hematomas of this type the treatment will be symptomatic; elevation and hot and cold compresses will be tried. Where the effusion is large and the pain is very intense, it will be necessary to release the imprisoned blood. This is done under strict antiseptic precautions and by a variety of methods (Fig. 256).

* All surgeons who deal with surgery of the hand are urged to consult the extremely valuable book by Bunnell.[1]

A useful method is to trephine the nail. This is done by taking a sharp scalpel and with a drilling motion, with as little pressure as possible, boring a hole through the nail and allowing the blood to escape. Other methods include the excision of a V-shaped piece of nail at the base and the forcing of a needle underneath the entire nail, beginning with the tip. In all cases after the release of the blood a sterile dressing should be applied.

Sheehan[5] reports an interesting case of thumbnail grafting. The patient had lost the thumbnail two years previously, and when first seen there was no longer any nail growth but a disintegrating mass at the lunula and cicatricial tissue beyond. The graft was taken from the other nail, and after three months the result was practically perfect.

Injuries from Pneumatic Drills.—A certain number of workers who operate pneumatic drills have always complained that their use causes "dead hands," attacks of blanching and numbness in the fingers with loss of power. The onset of symptoms is gradual and more noticeable in cold weather. The common finding is blanching or cyanosis of the fingers, which is usually symmetrical. If the blanching lasts for twenty minutes or longer, the finger tips become anesthetic, and a real disability is produced, as the man has no power to carry out the finer movements of the hands. The incidence of this condition increases in proportion to the number of years the worker has used the machine. In 1936 Hunt found that these workers exhibit a typical Raynaud syndrome.

McLaren[6] investigated three groups of workers who had used pneumatic machines. The first group (20 men) had used a machine which made 2300 strokes a minute. All these men had the typical circulatory changes, although the severity varied considerably. All were examined roentgenologically. Thirteen showed definite changes in the bones of the wrist and hand. This incidence of 65 per cent was very high. The typical changes found were the formation of "bone cysts," areas of localized absorption of bone occurring in the carpal bones and heads of the metacarpals The most frequently affected bones were the semilunar, os magnum, scaphoid and the metacarpal heads of the second and third fingers. The second group (19 men) had used machines of varying sizes and periodicity. Eleven of this group complained of the usual circulatory changes. The hands of 5 were examined roentgenologically, and 3 showed changes. Four of the third group (6 men) showed changes. There was only slight improvement when the men were given some other type of work. The osseous [illegible] As regards [illegible]

removed.[8]

Injuries from Injection of Oil at High Pressure (Oleomas).—Workers with Diesel engines may be injured by accidental contracts with the fuel oil jets, which have a pressure of 4000 to 6000 pounds per square inch. The fine particles of oil penetrate the skin and damage the subcutaneous tissues. The severity of the accident probably depends on the character and quantity of the oil and the pressure. In the case reported by Rees,[9] gangrene of the finger followed, and amputation was necessary. In one of Dial's[10] cases it was necessary to amputate the distal phalanx; in the other, slow healing occurred after incision and drainage of a sterile abscess and passive vascular exercises The treatment of this accident includes adequate early incision and the use of moist dressings. Smith[11] reports a case of injection into the finger of grease [illegible]
while greasing an automobile. I [illegible]
finger became gangrenous and [illegible]

[illegible] injury should consist in the removal of the foreign material as soon as possible before the pressure has led to irreparable vascular damage to the overlying skin This removal would require an extensive exposure and careful dissection under aseptic precautions. It seems probable that if this could be accom-

plished within a few hours of the injury, the patient might be spared the gangrene and inflammatory complications which follow injection in the fingers. If the patient is not seen until several days after the injury and gangrene is already developed, it seems most logical to maintain strict asepsis and allow a line of demarcation to develop before dealing with the gangrenous skin. A serious factor in the early case has been infection to which the devitalized tissues are predisposed, and every effort should be made to prevent secondary contamination. In the intermediate stage in which tumors have developed, but widespread manifestations are not present, extensive removal is definitely advisable. While it is difficult to recognize all of the involved tissue, it is worth while to make the attempt, in view of the progressively infiltrating nature of the process. . . . The late manifestations present a therapeutic problem which is often solved only by amputation. The presence of lipogranulomatosis in tissues far removed from the original site of injection and deep in the muscles and fascial planes, is evidence of the extensive dissection which would be necessary for complete eradication. Such eradication followed by skin grafting may offer some hope, however, in the occasional case."

Oil Tumors Following Hypodermic Injections.—Injection of camphor oil (liquid petrolatum) has caused invasive tumors and required excision.[15] A similar tumor from injection of estrogenic substance in sesame oil has been reported by Conrad and his associates.[16]

Incised wounds, lacerated wounds, puncture wounds and gunshot wounds *should be treated in the manner described in the section on wounds.* (See the section on open wounds and also important papers on this subject by Koch.[17]) The method of Koch[18] for the preoperative preparation of hand injuries is as follows:

"With the patient lying on the examining table the injured hand is laid on an arm board covered with a sterile towel. If the wound is oozing or bleeding profusely gentle pressure is maintained over the wound with sterile gauze held with sterile hemostats or a sterile gloved hand. The area about the wound and for some distance from it is shaved, and cleansed as carefully as possible with green soap and warm sterile water. If grease and dirt cannot be removed with soap and water, benzine or some other fat solvent is used, and followed again with soap and water. With the area about the wound cleansed, the gauze dressing is removed from the surface of the wound, and any loose particles or débris are removed from the wound itself. The wound is then irrigated with soapy sterile water and, if extensive and badly contaminated, scrubbed gently with sterile gauze 'sponge sticks.' Wounds and raw surfaces are not irrigated with tincture of iodine or other antiseptic solutions, since we believe that the harmful effect of strong chemical solutions on delicate and fragile tissue is greater than their potentially helpful effect as sterilizing agents. That antiseptic agents often stain tissues and make their recognition more difficult is of less importance, but worthy of consideration.

"If, as rarely happens in cases of hand injury, the wound is one in which complete débridement and primary or secondary closure are possible no cleansing of the wound itself is performed. Just before operation the skin edges immediately about the wound are painted with 5 per cent picric acid in 50 per cent alcohol or with tincture of iodine, and débridement is performed, with the result that the contaminated wound is converted into a clean wound. In only an occasional case of hand injury, however, is complete débridement possible, since structures essential to the function of the hand lie close to its surface."[19] McDonald and Webster[20] stress the importance of early covering with split-skin grafts of extensive traumatic deformities of the hand and foot. The student is referred to their valuable article.

Koch and Mason[21] have graphically described the art of purposeful splinting of the hand following injuries and infections. They say that at least three important principles are involved: "(1) securing rest for the injured and inflamed tissues, whether soft tissues, tendons, muscles, joint capsules or bones; (2) securing relaxation of muscles whose tendons have been divided or whose nerve supply has been injured; (3) bringing constant and prolonged tension to bear upon scar tissue whose gradual contraction interferes with the function of the hand. The studied application of these principles can aid very definitely in bringing about restoration of function after injury and infection have taken place." It is not always recognized that it is important to put infected tissues at rest. The aluminum splints described by Koch and Mason can be quickly made in the office or outpatient department by cutting from a sheet of aluminum the pieces of various shapes and sizes required.

Wounds from Aniline Pencils ("Ink Pencils," Indelible Pencils).—Wounds caused by aniline pencils must be given careful consideration. They commonly occur upon the fingers and hands of typists. Milch[22] states that the solution of the aniline dyes in the tissue juices produces an aseptic necrosis which develops slowly and is apt to be extensive. This author says that as attempts to remove the offending body may break it into smaller fragments, injure the protective wall about it and open the tissue spaces, the rational treatment is wide excision of the wound and the contained foreign body at the earliest possible moment. Gruzdev[23] demonstrated that the aniline dye contained in the pencil point causes a connective tissue necrosis with the formation of a zone of infiltration and granulations stained with the dye suggesting a rapidly growing, aseptic inflammatory tumor. He recommends immediate radical removal of the tumor. Wilmoth[24] reports a case of aseptic necrosis in the foot of a 13 year old girl six weeks after being wounded by an aniline pencil. The area of ulceration measured 4 by 5 cm. Healing followed wide excision of the ulcer. Wilmoth believes that the treatment of injuries from such pencils is immediate removal of the fragment that has penetrated the skin, with excision of the tract it has made through the tissues. De Puoz[25] has treated 33 injuries by "ink pencils" and recommends the radical excision of all tissues that have become discolored by the dye. Mason and Allen[26] say that when bones, tendons or other essential structures are involved and complete excision is impossible, the wound is left open and allowed to heal by granulation.

Defects of the Palmar Surface of the Finger.—When the wound has caused a defect in the palmar surface of a finger, the ingenious method of Gatewood which obviates hospitalization may be utilized. This operation is carried out under 0.5 per cent procaine anesthesia. The method of procedure is graphically given in the accompanying illustration (Fig. 257) from Gatewood's article. The surface of the palmar defect is carefully prepared. The finger is sharply flexed, and a pedicle flap of the palmar skin is reflected so that the under surface of the flap will easily correspond with the defect. After careful suture of the flap to the defect the flap wound edges are approximated.[28] A similar method is described by Jones.[29]

Finger Tip Injuries.—These injuries deserve special mention. Special care must be taken for the preservation of asepsis and the application of antiseptic solutions. The wound should *not* be tightly sutured and should be dressed

dry. Fractures of the distal phalanx are liable to infection because of anatomic considerations and the fact that virtually all of them are compound. If not compound at the time of the original injury, they generally become so because of the formation and subsequent liberation of a subungual hematoma. Hanrahan[30] says: "Regeneration of an intact fingernail depends on the complete integrity of its radix. When the radix has been damaged the injury is reflected in a faulty nail which may be thicker or thinner than normal, cracked, brittle, flaky, and frequently an excrescence which may be a thorough nuisance to its owner. Such a nail is far better removed and its regrowth

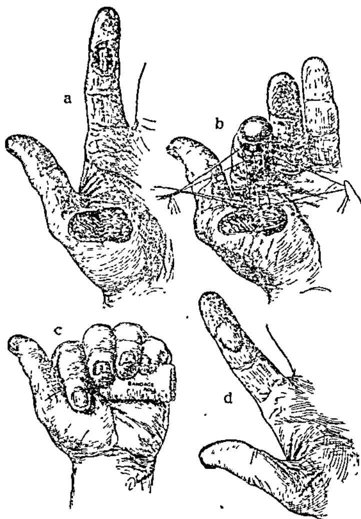


Fig. 257.—Steps in an operation for the plastic repair of finger defects without hospitalization. (Gatewood: J. A. M. A. 87: 1479, 1926.)

prevented by complete destruction of the diseased or injured radix. Simple removal of the nail is not enough; the entire radix must be removed. Removal of the radix destroys all nail growth and it becomes necessary to cover the defect. The application of a split graft on the nail bed meets the situation admirably. The graft really resembles a fingernail and the loss of the nail is apparent only on rather close inspection. This is one site where the difference in color and texture of the graft and that of the surrounding skin is an advantage." (See the sections on infection and on fractures of the phalanges.) Severe injuries to the finger tips are not uncommon. If ill-advised treatment

is given, there may result the sequestration of a portion of the distal phalanx or the formation of a painful scar. To obviate these possibilities, either sufficient bone may be removed to permit the skin to be approximated without tension, or a flap of skin may be transplanted from some other part of the body. The former course is the easier but entails the loss of some of the valuable finger.[31]

Wringer Injuries.—Allen[32] reports 107 cases of wringer injuries. The treatment is surgical cleansing, débridement and closure of the wound if possible. If it is not possible to close the wound, free skin grafts of intermediate thickness are used. "*The wound must be closed.*" A large pressure dressing and splint are applied. The dressing is changed in six to ten days. The extremity should be carefully observed for necrosis. As Hawkins[33] says, the "repair of these injuries may require not minutes but hours." Siler[34]

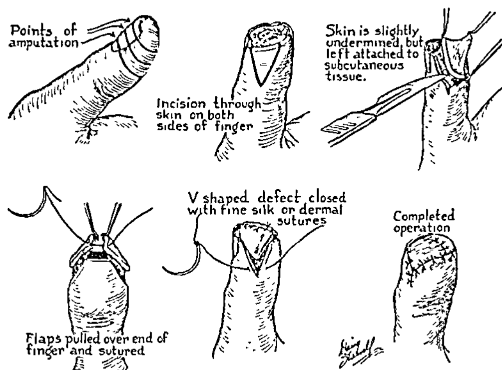


Fig. 258.—Triangular graft. (Kutler, W.: Ohio State M. J. 40: 126, 1944.)

says: "Wringer injuries are not limited to people working in the laundry. This injury is seen quite frequently in children. Since the rollers of the wringer produce equal pressure on the two sides of the extremity the injury is usually limited to soft tissue and produces contusion and usually bleeding into the tissue spaces. Only rarely are fractures seen with this injury. Occasionally large avulsive lacerations complicate the injury. If there has been no loss of the skin flap, grafting is not necessary. After proper cleansing and débridement of the wound the flap may be replaced and held there by sutures. We have had excellent results by placing the extremity on a sterile aluminum splint and applying a pressure dressing. Large hematomas of the dorsal subaponeurotic space respond well to this form of therapy. Aspiration is not usually indicated, but, if it is done, care should be used to prevent introduction of bacteria into the hematoma. Large avulsive wounds with loss of

skin should be covered by split thickness grafts immediately if the patient's condition permits."

Traumatic Amputation of the Fingers.—Injuries to the fingers are very common in industry and may be very extensive. All or portions of the fingers may be traumatically amputated, or the crushing may be so severe as to require amputation. Amputation of the tip of the finger may be treated by means of free full-thickness grafts after the method of Koch.[35] The triangular graft described by Kutler[36] is of interest. (Fig. 258) McCarroll[37] treated 45 consecutive cases of traumatic amputation of the finger by immediate application of free full-thickness grafts. In 43 of these cases there was complete "take" of the graft. McCarroll says: "The most important single factor in assuring the success of any free skin graft is the initial application and maintenance during the first few days of a firm, snug, pressure dressing. A

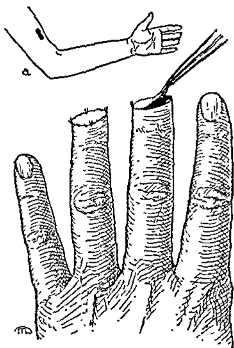


Fig. 259.—Free full-thickness graft to finger tip. (Koch, S. L.: Surg., Gynec. & Obst. 52: 594, 1931.)

single thickness of greased fine-mesh gauze (usually greased with vaseline or 4 *per cent.* xeroform ointment) is applied. In some instances, sulfanilamide powder has been dusted on the wound prior to dressing, and in others it has been purposely omitted. (The author has not been greatly impressed by the importance of this step.) Small gauze flats are then moistened so that they will mold more easily, and several thicknesses are placed over the finger tip in both planes. A small gauze bandage is then used to anchor them firmly in place, assuring smooth firm pressure to the entire finger tip. It is not necessary to extend the dressing beyond the base of the involved finger." The dressing is not disturbed until the sixth day and is changed thereafter every two or three days for about three weeks, firm pressure being maintained throughout.[38] (Fig. 259) Zadik[39] says: "Flap grafts should be used in all cases where the thumb is involved, where perfect function of the injured finger is essential to the occupation of the patient, where tendon is exposed or more

than about a third of the terminal phalanx is missing. Free full-thickness grafts may be satisfactory when only little bone has been lost and the injured finger is not essential." Zadik obtained better results when the finger was immobilized in plaster for a fortnight.[40] While it will be desirable to maintain as much length of finger as is possible it is important that the bone be removed sufficiently so that there will be ample skin to cover the end.

For the revision of a traumatic amputation of the fingers, *local anesthesia* may be employed. The technic of the production of local anesthesia in fingers is described by de Takáts[41] as follows: "At the base of the finger, the three pairs of small nerves that innervate the entire finger run in the subcutaneous tissue. A fine hypodermic needle is inserted at the base of the finger on the lateral side, closer to the dorsal surface (Fig. 260). Not more



FIG. 260—Blocking the finger with a local anesthetic solution. "Anesthetic solution is deposited close to the bone. Location of anterior and posterior nerves should be kept in mind and a greater amount of solution deposited about location of the nerves." (Pitkin, G. P.: Am. J. Surg. 8: 239, 1930.)

than 1 to 2 cc. of a 2 per cent novocain-adrenalin solution are injected on each side, the dorsal side getting a little less than the volar. Ultimately, not more than 3 to 4 cc. of a 2 per cent solution are used. The anesthesia of the whole finger begins in from five to ten minutes and lasts from two to three hours. Untoward symptoms, such as severe after-pain, swelling of the finger, and chronic edema, have been seen if large quantities, such as 10 to 15 cc. of a 0.5 per cent solution, are used. With the above technic there are no such symptoms. The adrenalin should never exceed 10 drops of 1:1000 solution to 100 cc., the finger arteries being practically end-arteries." The use of a rubber tourniquet at the base of the finger is painful and, according to de Takáts, unnecessary. O'Neil and Byrne [42] report eight cases of gangrene of the finger following digital nerve block. They say: "It has been found that the injected solution may interfere with the digital circulation and

produce gangrene if, first, too much solution is used or, second, if epinephrine is present in the solution or, third, if tourniquets are used. If the damage to the circulation is not sufficient in itself to produce the gangrene, subsequent soaking of the finger in hot or even warm water may hasten devitalization of the tissue. It is suggested that digital nerve block be replaced whenever possible by a general anesthesia using pentothal or gas-oxygen or ether. If it becomes necessary to use a local anesthesia, great care should be taken in performing the nerve block. No tourniquet nor solution containing adrenalin should be used. Only a small quantity of solution should be used, i.e., about 1 to 1.5 cc. for the entire block. Soaks should be contraindicated for at least twenty-four hours." In many cases, however, it will be necessary to use a general anesthetic. The skin is carefully cleansed with soap and water, and all débris and dirt are removed from the wound. If grease is present it may be removed with benzene. The adjacent skin may be painted with an

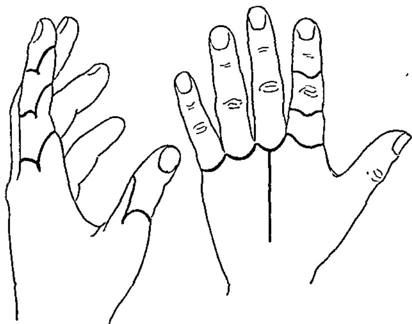


Fig. 261.—Lines of incision for amputations of fingers and thumb. (After Orr, T. G.: Modern Methods of Amputation, St. Louis, C. V. Mosby Co, 1926.)

antiseptic solution. The ragged and devitalized skin edges are then trimmed off. Careful thought should be given to the best manner of planning the flaps (Fig. 261). A long palmar flap, so that the suture line is on the dorsum of the finger, is always best, if possible, as a tender scar on the palmar surface of the finger may be the subsequent cause of great annoyance (Fig. 261).

Couch[43] believes that amputations through fingers are the most unsatisfactory ones which surgeons perform and says the reasons for disappointing end-results are as follows:

"*Short Flaps.*—These are probably the most common cause of painful results. Flaps in fingers should be twice as long as in thigh amputations—relative to the size of the part; that is, the total of the two flaps in a finger should equal twice the diameter of finger. This is necessary because such a large proportion of the finger is occupied by hard, unyielding bone and fibrous tissue, while in the leg the bone is relatively much less. Skin flaps always shrink.

"*Neuromas.*—Often painful bulbs develop on the end of the digital nerves. Such bulbs are close under skin or even in the scar and are exquisitely painful on pressure. They may set the stage for causalgia. Obviously, then, at operation it is always desirable to locate

the digital nerves, draw them down and cut them off short, allowing the end to retract far away from scar.

"*Stiff Joints.*—The old principle, 'save all you can—it may live,' is wrong, because it thinks in terms of anatomy rather than physiology. There is no point in saving fingers so badly smashed that they can never be useful. Many a patient comes back, after a year of useless suffering, to have a stiff, distorted finger removed. If it had been removed primarily, he would have been back to work in a few weeks. Save function rather than form. In general, go high enough so that amputation is through vital tissue, hence prompt healing and early movement. A crushing of two bones, with a shattered joint between, calls for removal. Joints so badly disorganized as to become stiff are no good. Shredded or missing tendons render a finger useless. If pus is present, never amputate through bone—disarticulate if necessary.

"*Wrong Level.*—In the leg, definite levels are recognized as giving best results. All are familiar with the advantages and disadvantages of a Syme's, a 'below-knee' and a Gritti-Stokes. In the arm, and particularly in the hand, no such clear concept has been offered. Yet the many who return asking the removal of stumps, which are worse than useless and which invite further injury, suggest that some amputations are more satisfactory than others.

"Since the thumb is the most important member of the hand, the rule is to save as much [illegible]

and many insurance companies give no disability allowance.

"If the injury to the left index forces amputation any higher than the proximal joint, one should *immediately amputate well proximal to the head of metacarpal*, because *a short left* index stump is useless and likely to be hit at work. The metacarpal should be beveled so that no useless hump remains between middle finger and thumb to cause months of inefficient work and culminating in reamputation. A short right index stump may at times be permitted as a guide in handling tools, even though it adds little to the grip.

"Save as much of middle and ring fingers as possible. These stumps lend strength to the grasp and keep the index in line. Disarticulation at the knuckle joint is not good. The head, [illegible]

and should be replaced by a beveled amputation halfway down the shaft of metacarpal."

Hawkins[44] says he has "long ceased to scoff at the patient who brings in the severed portion of the finger. Usually if seen within a short time careful cleansing and application of the severed segment will result in a take."

[illegible]

appears to be a very rough piece of surgical work will produce a fairly good functional result."

In discussing finger amputations, Webster[46] says: "Flexor tendons need not be sutured to bone or tendon sheath in clean cases and must not be overlapped and sutured over the end of the bone to the extensor tendons. Disability, with weakness of the grip, results. In contaminated or infected cases, they should be anchored at the point of amputation and the tendon sheath left open to avoid spread of infection to the hand. Such tendons may become adherent and produce disability. They should be excised to free the finger, relying on the intrinsic muscles of the hand for motion of the stump."

Webster describes a tendon stripper suitable for freeing the tendons in the hand. Students are referred to his excellent article.[47]

The fine saw is preferable to the bone-crushing forceps. The skin edges are loosely sutured with a few interrupted silk sutures. If a tourniquet has been employed, it is now removed, and if a spurting vessel is disclosed it is clamped and ligated. When hemostasis has been effected, a vaselin dressing will be applied. Wet dressings are inadvisable. A tongue depressor splint will be fastened to the outer part of the dressing so that it projects ½ inch beyond

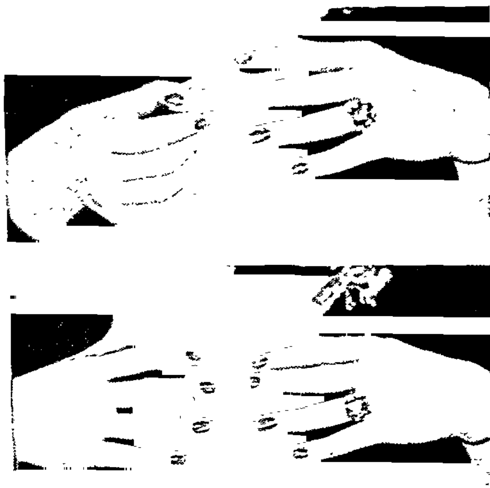


Fig. 262.—Prosthesis for loss of finger tip. Prostheses of this type can be fitted to finger snugly and securely without adhesives. The fingernail is removable. (Brown, A. M.: Am. J. Surg. 68: 338, 1945.)

the finger tip for protection. Aluminum finger protectors may now be purchased. Unless throbbing and increased pain give evidence of infection, the dressing will not have to be changed for a week. The removal of dry and adherent gauze will be facilitated by soaking the finger and bandage in a vessel of sterile warm boric acid solution or hydrogen peroxide solution. These wounds which become secondarily infected will be dressed daily and warm boric acid dressing may be required. The stitches are removed on the sixth to the tenth day. Prosthetic restorations after amputations about the hand have been described by Brown.[48] (Fig. 262)

"Auto Door Finger."—Pinching of fingers in a slammed door of an automobile is a very common occurrence. This occurs particularly in children and is generally accompanied by some subungual hematoma. This will be treated as previously described. Very often all or part of the base of the nail is found to be protruding above the eponychium.

In this event the loosened base of the nail is cut off, leaving the distal attached portion in place (Fig. 263). It is well to be sure that *all* of the base of the nail is removed if this is done. The lifting up of the nail corner is facilitated with a small hook. It is well in all cases of "auto door finger" to take an *x*-ray film of the distal phalanx. This can conveniently be done with a dental film. A linear or comminuted fracture often will be disclosed. The fragments are rarely out of position. These painful fingers are best treated by the use of first cold applications and later hot applications. Mock and Ellis[49] advise the incision of these very painful fingers. If there is a subungual hematoma it is thus relieved. If no hemorrhage appears beneath the nail, an "alligator mouth" incision is made through the theca ⅛ inch below the nail and across the full width of the finger back to the injury. The author believes that this procedure will be but infrequently necessary and has the disadvantage

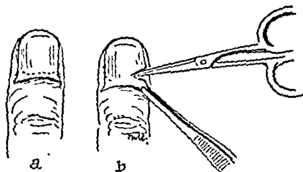


Fig. 263.—*a*, Extrusion of nail root following contusion of the finger. *b*, Resection of the extruded nail root.

of converting a simple fracture into a compound one. Nitrous oxide or ethylene is preferable to a local anesthetic for use when incising a finger tip. If a local anesthetic is used, the nerve block is preferable to infiltration. A tongue depressor will be loosely bandaged to the affected finger. Early motion, that is, beginning on the third to the sixth day, is to be insisted upon. The patient should be warned that the tenderness may persist for seven to twenty days.

Lacerated and Incised Wounds of Tendons.—Tendons are commonly severed by sharp instruments. The porcelain faucet handle is a particularly prolific cause of tendon injuries. When we are more enlightened our building laws will permit only chrome-plated metal handles to be used.[50] In five years at the Mayo Clinic, 12 injuries of the hands from porcelain water faucets were recorded.[51] In all wounds of the fingers, hands and forearms which penetrate beneath the skin, tests should be made to establish the presence or absence of continuity of the tendon. No matter how painful the wound is or how reluctant the patient is to attempt it, flexion and extension of the fingers and hand should be demanded. If there is limitation of the motion of the fingers or hand, tendon injury will be evident. One should be on particular watch in wounds of the palmar surface of the fingers or hand that flexion at

the distal interphalangeal joint is not interfered with. If there is inability to flex the distal phalanx, the diagnosis of section of the flexor digitorum profundus may be made. The tests for tendon injury are shown in figure 264, which is taken from Koch's[52] article.

Koch[52] states that "an immediate repair of divided tendons is justifiable if the wound is a clean-cutting wound, made by sharp instruments, if the wounded hand is clean, if the cut is sustained indoors, if the first-aid dressing has been sterile, if the patient is seen within a few hours of the time of injury, and if a well-equipped operating room is available for surgical treatment. If these conditions are not present we believe it is wiser to close the superficial wound loosely with a few interrupted sutures and permit healing to occur before attempting a repair of the injured tendons. We are particularly conservative about attempting immediate suture of tendons surrounded by a



Fig 264.—A, Test of finger tendon. If the proximal phalanx of the thumb is fixed, active flexion of the interphalangeal joint is due solely to the action of the flexor pollicis longus. If the muscle or tendon is injured or divided, flexion is limited or the thumb remains fixed in extension. B, Test of finger tendon Position of the finger after division of the flexor profundus; active flexion at the proximal interphalangeal joint is produced by the flexor sublimis, but the finger remains extended at the distal interphalangeal joint. C, Test of finger tendon. If the flexor profundus is intact, the finger can be flexed at the distal interphalangeal joint. (Koch, S. L.: Surg., Gynec. & Obst. 52: 594, 1931.)

sheath. We have on several occasions seen cases in which the suture of tendons on the back of the hand has been followed by a slight localized infection without serious impairment of the operative result, but we can recall but one case in which a low-grade infection developed after suture of flexor tendons without impairment of the final result. In the majority of such cases which have come to our attention there has been extensive spreading of infection with eventual necrosis and sloughing of tendons, and in some cases sloughing of superficial tissues and ankylosis of joints as well, conditions which make it necessary to postpone any attempt at operative repair for long periods of [illegible]

[illegible]

whether immediately or at a later date, every effort should be made to ensure healing by primary union, for in securing a successful result nothing in the way of accurate apposition, careful suture or painstaking postoperative care can compensate for failure to secure wound healing without infection.

"In the technic of operation gentleness in the handling of tissues, accurate apposition of tendons, end-to-end apposition of healthy nerve ends, the use of fine suture material, and the employment of a bloodless field during the operative procedure are important details. Properly designed splints, and skillfully applied physical therapy are important and helpful adjuncts in securing successful results in the shortest possible period of time after operation."

Alexis Carrel is reported to have said that he considered the restoration of function to damaged tendons of the fingers the most difficult of surgical problems.[54] The operation of tenorrhaphy will be best carried out under general anesthesia, although local may be used. Elaborate precautions must be taken to insure asepsis. The entire hand will be scrubbed with soap and water, dried and painted with antiseptic solution, preferably 7 per cent iodine, before being draped with sterile linen. General anesthesia will be preferable, and a good light and adequate assistants are indispensable. Koch[55] emphasizes the importance of a bloodless field in operating on tendons. This is secured with a blood pressure apparatus pumped to 220 mm. of mercury. "Just before the operation the arm is elevated for a few moments and the blood-pressure band inflated. When dissection is completed and the tendons are ready for suturing, the constriction is released, the wound examined carefully and the bleeding vessels ligated." It may be very difficult to locate the severed ends of the tendons. Every effort should be made to cause the proximal end of the tendon to protrude from the wound by milking the tendon down by external pressure and by acutely flexing or extending the fingers or hand, as may be indicated. Rockey[56] describes a very useful procedure for severed wrist tendons which he learned at the Massachusetts General Hospital. A large, soft rubber tube is "wound around the forearm beginning at the elbow in a spiral fashion, each lower coil touching the coil above," and this winding is continued downward almost to the wrist. The severed tendons are pushed down toward or into the wound. Moser[57] has described a method of artificial muscle relaxation by the employment of a local anesthetic. When it is injected into the muscle substance it produces a lengthening of the muscle and makes the central tendon stump more accessible. McNealy and Lichtenstein,[58] who studied this subject experimentally, concluded that the injection of novocain into the muscle belly definitely lessens the retraction of a severed tendon and that "in the unanesthetized dog, this nerve influence following a single injection lasts a variable period of time from thirty minutes to four hours." Repeated injection will induce continuous muscular relaxation. When there is multiple section of the tendons and nerves at the wrist, identification of the structures is often difficult but of extreme importance. Kaplan[59] has made a careful study of the anatomy of the tendons of the wrist and of the median nerve and finds that there is "a comparatively constant relation of the tendon of the palmaris longus to the median nerve and tendon of the flexor profundus indicis." (Fig. 265)

In a tenorrhaphy on a finger in which the original skin wound has completely healed, the incision to expose the ends of the cut tendon should be made at the *side* of the finger. Failure to do this may bring about a contracted midline scar which will prevent extension of the finger.

Blum[60] advises a transverse incision in the belly of the appropriate muscle to facilitate suture and healing of flexor tendons in the hand. Bunnell[61] says:

"In recovering tendons for suture, a prevailing fault is to continue an incision upward along the tendon—namely, to make the 'pernicious median longitudinal incision' that cuts across natural creases and pulleys, and leaves a maximal length of adhesions along the tendon resulting in keloids, flexion contracture, loss of gliding surface, bowing forward of tendons, and immobility from adhesions. Instead, a small transverse incision higher up will suffice or a mid-lateral one in the finger. Care should be taken to avoid crossing flexion creases at a right angle or injuring small nerves."

Mayer[62] says:

"If the cut extends across the proximal phalanx of the fingers, the distal stump of the flexor profundus will be found to be only ¼ inch long; the proximal stump will usually have retracted about 2 inches. Realizing these facts in advance, the surgeon plans his incision

Fig. 265.—A dissection of the anterior aspect of the wrist combined with a cross section of the flexor tendons and the median nerve. (Kaplan, E. B : J. Bone & Joint Surg. 27: 368, 1945.)

accordingly. It is a waste of time to 'fish around' in the wound itself for the divided stumps. This merely traumatizes and increases the risk of failure. Small incisions should be made at the points
should be pla
crease at a rig
It is my habi
digital nerves ... exposed, then the knife may be used again." The method described by Murphy[63] in dealing with section of the flexor pollicis longus tendon may be used. Murphy says: "The distal end of the
To obtain the proxin
from the wound to a
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between the flexor

Miller[65] found good results in 84 per cent of the cases. In 87 flexor cases there were good results in 79 per cent, and in the 49 extensor cases there were good results in 92 per cent. Bunnell[66] gives the following method of uniting tendons end to end without traumatizing the delicate epitenon, and his illustrations are herewith reproduced (Fig. 266): "As shown in *A*, with the tendon held taut by a Kocher hemostat, one of two needles is passed through it diagonally, starting about 1 cm. back. Three similar stitches in all are taken with this needle. At each the needle reenters the tendon a short transverse distance from where it emerged and finally the needle emerges 2 or 3 mm. from the hemostat, but on the opposite side of the tendon from where it first entered. In *B* is shown the other needle starting its first stitch ransversely across the tendon, entering only a few fibers away from where

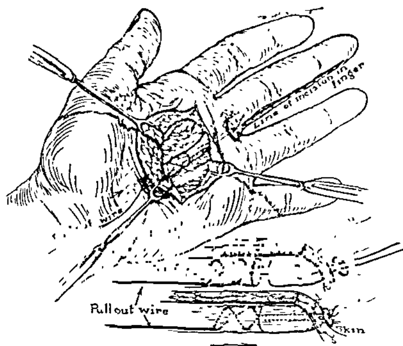


Fig. 267.—Suturing a tendon in palm by removable stainless-steel wire. In three weeks the tendon will have joined and the suture after being cut beneath the button may be withdrawn backward by the pull-out wire which is looped about it. (Bunnell, S.: Surgery of the Hand, Philadelphia, J. B. Lippincott Co, 1944)

the first needle entered. (Reversed in the diagram.) With this needle three diagonal stitches are then taken, just as with the first needle, emerging from the tendon directly opposite where the first needle emerged. The traumatized cicatricial tip of the tendon is snipped off, as in *C*, and in the insert the stitch is shown as it will be when finally placed. In *D* while the tendon is held taut over the finger by one suture, the other suture is passed back through the point where it emerged [illegible]

[illegible] suture opposite it which emerges from the end of the other tendon and the result is as shown in the insert." Of recent years Bunnell[67] has preferred fine stainless steel wire, sizes no. 34 and 35, to silk for tendon suture. His method of using stainless steel wire in the interval repair of tendons is shown in figure 268. Bunnell has also devised a method of tendon repair with stainless steel wire in which the wire may be removed after three weeks. He says:

"After three weeks a silk suture has fulfilled its mission and if it remains is merely an irritating foreign body." The method is shown in figure 267. By means of the pull-out wire, the tendon suture is removed at the end of three

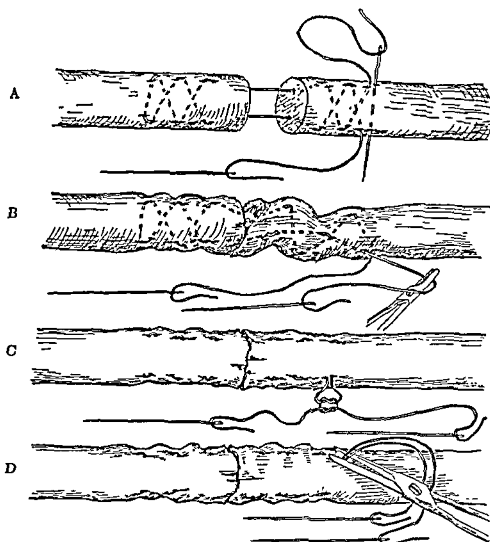


Fig. 2 [illegible] steel wire. This stitch is too elab[illegible]
pounds. [illegible]
than that of silk. Where it has been subjected to constant angular movement, [illegible] do no harm [illegible]

[illegible] being again passed through the tendon, so they will be left [illegible] (Bunnell, S : J. Bone & Joint Surg. 23: 240, 1941)

weeks. For primary repair of flexor tendons in the palm or forearm with stainless steel wire, Bunnell advises the double right angle stitch shown in figure 269.[68] O'Shea[69] uses simple mattress sutures plus approximation sutures. He advises against repairing both digital flexors in the hand. Only

the flexor profundus digitorum should be sutured. Koch[70] says that the profundus alone, if accurately united, gives an excellent functional result.[71] Baumann[72] makes an end-to-end suture with no more than two (usually one) twisted or silk sutures. The use of suture material which is fused to the needle will cause less trauma to the tendon. The cutaneous wound should, if possible, be made arch shaped, with care that the wound does not lie immediately

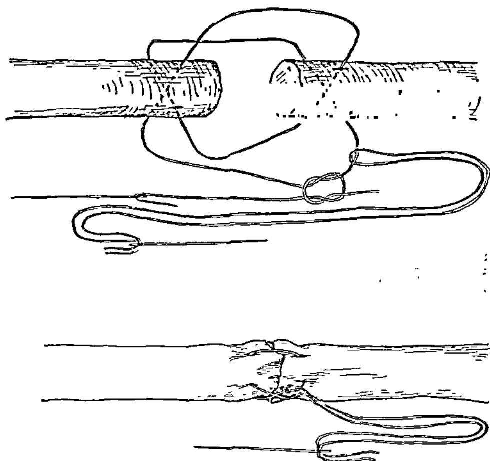


Fig. 269.—Double right-angle stitch. The stitch is more than twice as strong as two simple through-and-through stitches because in each tendon end the stitch crosses diag- [illegible]

[illegible] is *per primam,* the pull-out wire may be withdrawn. (Bunnell, S. J. Bone & Joint Surg. 23: 240, 1941.)

over the tendon suture. Baumann advises heat, exercise and light massage after two weeks with guarding against overextension for another week. The metal anastomosis tubes of McKee[73] are interesting but have the disadvantage of requiring a second operation at five weeks to remove them. For a description of the use of tendon grafts, a recent article by Koch should be consulted.[74]

Koch[75] has operated upon 46 patients who had flexor tendon injuries

"Two minutes' examination of the hand for sensory loss is sufficient to indicate definitely the presence or absence of nerve injury (Figs. 272, 273)." In freshly lacerated wounds of the wrist and forearm in which the severed ends of the nerve may be identified, it will be proper at the time of the first repair of the wound to approximate the cut edges of the nerve. This will be done with very minute sutures of plain or chromic catgut which are passed by very fine needles through the epineurium so as to produce end-to-end approximation. "Fused needles" are of value. The portion of the nerve distal to the section will then be centrifugally regenerated over a considerable period of time. Marble and his associates[80] report on 110 injuries of the ulnar, median and radial nerves, with 84.5 per cent satisfactory end-results. In their cases the average rate of regeneration was between 1 and 1.5 mm. per day. If the suture of cut nerves is neglected at the time of the original operation, the secondary suture will be far more difficult because of the presence of confusing scar tissue, and the services of a neurosurgeon generally will be required. From an experimental study upon the prevention of adhesions

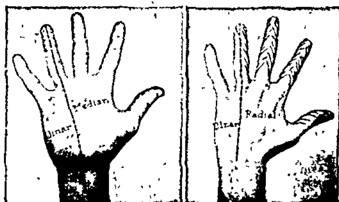


Fig. 272.—The sensory distribution of the median, ulnar, and radial nerves in the hand. Absence of the tactile and pain sense in any of these areas indicates that there has been a crushing, tearing, or division of the nerve supplying the affected area. (Koch, S. L.: Surg., Gynec. & Obst. 52: 594, 1931.)

about repaired nerves and tendons, Davis and Aries[81] concluded that allantoic membrane caused the least reaction about traumatized nerves and protected the nerve from the growth of scar tissue from the surrounding tissue bed. Even better results were obtained if the allantoic membrane was covered with a flap of fat.[82]

Wounds of Muscles. (See the section on Ruptures of Muscles.)—Extensive lacerated wounds will occasionally involve the muscle bellies. The laceration may be extreme and accompanied by considerable herniation of the muscle belly from its fascial envelope. It will be necessary to make an attempt to restore the continuity of these injured muscles. This will be done by the introduction of a *few* mattress sutures. Too zealous efforts to make the approximation anatomically correct may only favor the development of secondary infection. These traumatic wounds are best thoroughly drained, and if there is considerable introduction of dirt and the edges of the wounded muscle are jagged and devitalized, it will be better to débride, leave the wound open and institute Carrel-Dakin treatment. Traumatic wounds involving muscles never should be closed without drainage.

Wounds of joints are far less common in the upper extremity than in the lower because of the extreme frequency of involvement of the knee. The guiding principle in the treatment of all joint wounds is the closure of the joint capsule without drainage. Where there has been introduction of considerable dirt or infected material, a proper preliminary to the joint closure will be irrigation with a very mild antiseptic solution, such as warm boric acid solution. This will remove the blood clots and gross dirt. Ragged bone

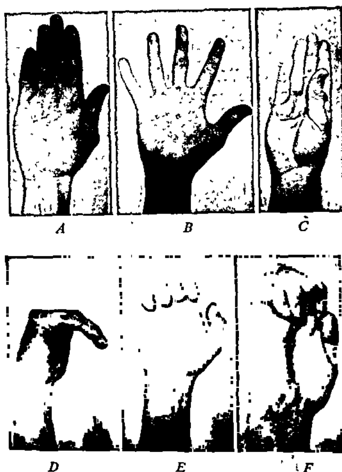


Fig. 273.—Adduction of the fingers toward the middle finger (*A*), abduction of the fingers from the middle finger (*B*), and adduction of the thumb toward the hand (*C*) are carried out by the [illegible]

[illegible] of the forearm the power of flexion at the metacar- [illegible] joints by [illegible]

or cartilage will be curetted or chiseled out. The joint capsule should then be tightly closed with a continuous suture of catgut. The soft parts overlying the joint wound then will be approximated with interrupted stitches and will be drained down to the joint with rubber tissue or rubber drains. A more contaminated wound may be left entirely open down to the sutured joint capsule or merely loosely approximated. Early mobilization of the wounded joint will be encouraged and demanded, the active motion being more important than the passive motion. When the external wound has healed,

if the joint is still somewhat stiff, the active motion may be supplemented by passive motion, massage, hot fomentations and diathermy. Baking with radiant heat is somewhat beneficial.

Hansen[84] reports on open wounds of the joints treated in the Bochum Hospital in the period from 1925 to 1930. The 75 joints involved included 37 knees, 21 foot joints and 17 elbows. The basis of the treatment of such wounds consists of immediate closure after extensive excision of contaminated and frayed tissues, the removal of splintered bone and cartilage, the reduction of fractures and dislocations, and irrigation with phenol camphor, a small amount of which is left in the joint. Menisci are extirpated and not sutured. After several days of rest in a Volkmann splint, the joint is carefully exercised. In the cases of wounds of the elbow joint there were no fatalities. The chief cause of permanent disability was arthritis deformans. Of 17 patients with wounds of the elbow, 11 recovered with no disability, and 3 had a permanent disability ranging from 25 to 50 per cent.

Foreign Bodies.—The common foreign bodies found in the upper extremities are fragments of glass, splinters, sewing needles and various missiles.

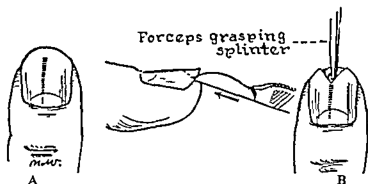


Fig. 274.—Removal of a subungual splinter. The splinter generally, but not always, may be seen through the nail (*A*). A V-shaped piece of the nail is excised the scalpel being pointed upward so that it will not inadvertently injure the nail bed. The splinter is withdrawn with a small mouse-tooth forceps (*B*).

Their removal will be effected by the methods detailed in the section on foreign bodies.

Subungual Splinters.—Wood or metal splinters are frequently embedded beneath the finger nail. They generally will be visible beneath the nail, but not always so in the case of thick nails. Occasionally dirt left after the withdrawal of the splinter gives the erroneous impression that the splinter is still there. These splinters always should be removed as soon as possible in order to prevent serious infection. Excision of a small V-shaped wedge at the edge of the nail may permit a grasp of the splinter, but more often it will be necessary to cut out a longitudinal slot from the nail. This can be done with little or no pain if the finger and nail are firmly grasped in one hand and the nail is carefully cut with a sharp curved scalpel. The scalpel should be so directed that its point does not enter the matrix, and so that if it slips it will go above rather than below the nail (Fig. 274). The splinter is best withdrawn with a splinter-grasping forceps, which is a fine pointed hemostat without the ratchet catch.

Sprains may be defined as wrenches of joints. (See Sprains of the Ankle.)[85] There will be an overstretching of the joint capsule or of the various support-

ing joint ligaments or tendons, both inside and outside the joint. In the milder cases or strains there is but microscopic overstretching of these structures, and but a few individual fibers are injured. From these lesser injuries all grades of traumatism will be encountered up to complete lacerations of the joint ligaments with abnormal mobility and partial luxation of the joint itself.

By the term sprain is meant an injury which involves minute traumatism only, as the rupture of individual fibers. By the term torn ligaments is meant a more severe injury with abnormal mobility of the joint.

Jennings[86] says: "The importance of differentiating between a simple ligamentous sprain and a joint sprain cannot be overemphasized. In the former, active motion can, and should, be permitted immediately to prevent muscle atrophy, shortening of the ligaments and painful adhesions." In joint sprains the effusion in the joint is marked, the synovial membrane has been injured and there should be one to two weeks of immobilization. Jennings recommends firm bandaging and elevation of the joint during the acute stages to prevent excessive effusion. He says that chronic sprains are the result of prolonged immobilization and repeated injury. Leriche suggests that the essential pathologic feature in ligamentous sprains is injury to the nerve plexuses of the ligaments. He believes that the effusion is the result of a vasomotor disturbance caused by the reflex stimulation of injured peripheral nerve elements.

A sprain often is accompanied by traumatic synovitis; the synovia secrete an excessive amount of fluid and the joint capsule becomes painfully distended. The shoulder, elbow and wrist are less liable to fluid accumulation than is the knee. In sprains there is a very definitely localized pain in the joint vicinity which is occasioned by certain motions. "The pain is caused by active contraction against resistance, or passive stretching of a muscle, or a certain group of muscles or ligaments. There is a tender spot, perhaps not larger than a nickel, at the attachment of a tendon, and a small swelling with a suggestion of edema or fluid may be palpated deep down on the surface of the bone. This tender spot which is the key to the diagnosis is a small patch of effusion below the periosteum, or in the fibers of the tendon attached to the bone constituting the origin or insertion of the muscle. The pain is due to tension on this effusion by pressure on the muscle or by direct pressure on the edematous spot."[87] There is often swelling of the subcutaneous tissues. In the lesser sprains elevation and cold applications will facilitate this absorption and mitigate the pain. The joint should be bandaged or strapped with adhesive plaster in such a position as will best secure the approximation of the injured fibers. A pad strapped over the tendon above the sprain will often provide an effective splint of the injured part. Once the injured part has been splinted, active motion is to be encouraged provided this is not painful. The more severe sprains with joint effusions may be treated, as has been pointed out by McWilliams, by repeated aspirations of the joint and by early mobilization. The aspiration of the joint will be carried out with strictest attention to asepsis. The skin will be painted with 7 per cent tincture of iodine and the aspirating needle carefully introduced into the distended joint capsule. As a prophylaxis against infection, penicillin may be given. Balboni and his associates[88] showed that intramuscular injections of penicillin penetrated rapidly into joint fluid.

Some surgeons advise making a very short incision in the skin at the site of the puncture as prophylaxis against the introduction of organisms into the joint.

The removal of the excess fluid will greatly relieve the patient's sufferings. A very severe wrench of a joint may cause the effusion of blood into the joint, a condition known as hemarthrosis. Its treatment will be identical with that of serous effusions and includes early aspiration.

The commoner sprains of the upper extremity are those involving joints of the fingers, the wrist and the elbow. Owing to its extreme mobility the shoulder is practically never sprained. The joints of the upper extremity rarely will require aspiration as a treatment for sprains. This treatment is most frequently applied to the knee and less so to the ankle joint. When

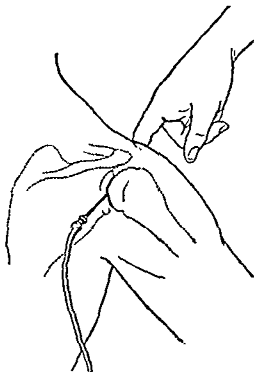


Fig. 275.—Posterior puncture of the shoulder joint. The needle is inserted just distal to the base of the acromion between the posterior border of the deltoid and the tendon of the infraspinatus. The finger is on the coracoid process in front. (McWilliams, C. A., in Lewis, D.: Practice of Surgery, Hagerstown, Md, W. F. Prior Co., Inc., vol. 2, chap. 5.)

several times daily. It must be pointed out that a good part of the swelling which occurs in sprains is due to extra-articular effusion as well as to the intra-articular effusion. It is the extra-articular effusion which particularly is susceptible to treatment by contrast baths and later gentle massage. A woven knit bandage is helpful for wrist sprains. Early careful active mobilization is indicated. When the injury has been so marked as to cause abnormal mobility of the joint, the treatment will involve prolonged immobilization to secure the proper union of the torn ligaments and capsule. A measure advocated by some in the treatment of sprains is the application of a snugly applied pad upon the area of effusion.

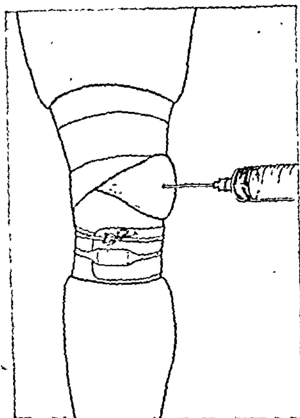


Fig. 276.—Rubber bandage applied to a knee joint partially filled with fluid. The elastic pressure forces the joint fluid to one localized area. The impairment of circulation to this area results in complete anesthesia. Elastic pressure forces the fluid into the syringe. (Goldberg, D.: Am. J. Surg. 68: 89, 1945.)

Leriche and others[90] have had considerable success in the treatment of sprains by injecting from 10 to 20 cc. of 1 per cent novocain solution in the region of the articular ligaments, particularly at the most tender sites. The reflex nerve stimulation is eliminated, and the beneficial effect lasts longer than the local anesthesia.

x-Ray examination always should be made when there is considerable pain and swelling or when mild symptoms do not rapidly subside.

Rupture and Dislocation of Tendons and Muscles. (See the discussion of ruptures of individual tendons in later sections.)—Subcutaneous tendon ruptures have been classified by Stapelmohr[91] as follows:

(*A*) Direct trauma: tendon caught between bone and traumatizing agent.

(*B*) Indirect trauma: forcefully contracted tendon subjected to forceful passive force in the opposite direction.

(*C*) *Spontaneous rupture:*

1. Post-traumatic: aseptic necrosis or degeneration of tendon due to single severe or often repeated minor trauma.
2. Disease of tendon: tuberculosis, gonorrhea, syphilis, gout, etc.

Haldeman and Soto-Hall[92] conclude: "Certain features are common to most ruptures of muscles. The history of a sudden sharp pain or snapping sensation, which occurs during violent muscular effort and is followed by the inability to perform certain definite movements, is very suggestive. The *appearance of a defect in the belly of the muscle or in the* tendon and the subsequent development of ecchymosis makes the diagnosis more certain.

"Among diagnostic aids, if the lesion is not accessible, should be mentioned the lightly exposed roentgenogram which shows the soft tissues, electrical stimulation and the local injection of procaine hydrochloride. The former often shows a defect in the shadow cast by the muscle and may reveal a small chip of bone attached to a tendon that has been torn from its insertion. The faradic current, when applied to a muscle, causes it to contract, with [illegible]

"From our statistical study it appears that in the upper extremity the supraspinatus muscle or tendon is the most likely to be torn, while in the lower extremity the quadriceps is most vulnerable. Senility appears to play a more important rôle in the former than in the latter condition. In view of the prevailing belief that a degenerative process is a prerequisite of the rupture of a muscle or tendon, it was interesting to find that the average age of the patients in our series was forty-two years, which corresponds to that period in which the greatest activity is associated with the onset of degenerative changes In our series of 100 patients, 83 were males, which fact can be attributed to the predominance of *men in those branches of industry which require violent muscular effort and entail the risk* of falls and other injuries.

"The rôle of acute trauma seems to be much greater than all other causes of injury to muscles, including age, disease and chronic trauma. The most common mechanism pro- [illegible] whereas in a [illegible] strain, the tendon does not rupture. However, rupture may occur at the insertion of tendon to bone, at the musculotendinous junction, through the belly of the muscle, or at its origin from the bone. Either muscle or tendon may pull away a small fragment of bone. Sometimes the strain results in fracture or dislocation." (*x*-Ray examination of the bony attachments should be made in cases of rupture of tendons.)

"*Drop Finger* (*Mallet Finger; Baseball Finger*).—A blow upon the tip of the extended finger, such as is frequently caused by a baseball, results in the condition known as "drop finger." *In this injury there is rupture of the* dorsal surface of the distal interphalangeal ligaments and capsule, as well as the prolongation and insertion of the extensor tendon. There may be a minor fracture at the base of the terminal phalanx in the region of the insertion of the extensor tendon (Fig. 372). As a result the patient will be unable to extend the distal phalanx, which is therefore dropped or flexed, with an annoying disability (Fig. 277). The treatment of this condition is apt to be somewhat difficult and prolonged. Therapeutic measures are the application of a short splint or an operation. The most useful splint is one which is cut from a sheet of aluminum to fit the size of the patient's finger. The splint is padded with felt and applied to the dorsum of the finger. It is bent so that

there is flexion at the proximal interphalangeal joint and hyperextension at the distal interphalangeal joint. The correct position is shown in figure 278, a case in which plaster of paris was used for immobilization. Saypol and Slattery[94] have found plaster of paris satisfactory for immobilization. They say that the plaster "should be snugly applied, and a dorsal section corresponding to the shape of the nail should be cut out so that the finger tip may be observed for circulation. Care in the original splinting, with observation for the first 12 to 24 hours, may make the difference between union of an avulsed fragment to its bed and a permanently 'dropped finger.' For cases

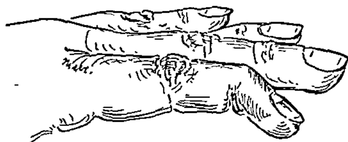


Fig. 277.—"Drop finger." Rupture of the digital extensor at the distal phalangeal articulation."

seen after the first week, open operation is usually necessary. This procedure is recommended only for those in whom the distal phalanx is an encumbrance." Excellent waterproof finger casts can be made from glass plastic bandage.* If the finger is not held in marked hyperextension, the tendon may heal in a lengthened condition, and further shortening by operation may be necessary. Flexion of the finger will not be permitted for a period of from four to six weeks or longer. When the splint is to be changed because it is too soiled or the finger must be washed, even momentary flexion of the

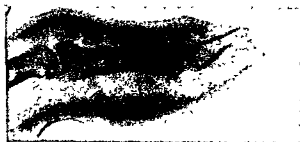


Fig. 278.—Position for immobilization of "baseball finger" in plaster. (Saypol, G. M., and Slattery, L. R.: Surg., Gynec. & Obst. 79: 522, 1944.)

distal phalanx should not be permitted; it should be held in an extended position. Farquharson[95] believes that "if the finger is immobilized with both interphalangeal joints in extension, the torn tendon is still subjected to strain produced by voluntary extension at the metacarpophalangeal joint." He says that "this strain can be prevented if the proximal interphalangeal joint is flexed. In this position, the central slip of the tendon, together with the whole extensor expansion, is pulled distally and fixed; the terminal part of the tendon is slack and out of action, and is unaffected by movement at

* "Aire-Lite," The Tower Co, Inc., Room 665, 120 South La Salle St., Chicago.

the metacarpophalangeal joint." (Fig. 279) Farquharson advises, therefore, that the finger should be immobilized for five or six weeks "not only in hyperextension at the terminal joint, but also *in right-angled flexion at the proximal interphalangeal joint.*" To this end he applies a small plaster cast. Dry plaster is wrapped about the finger, which is then immersed in water. The wet plaster is then molded into shape with the patient holding the finger in the proper position. Mason,[96] in speaking of this condition, says:

"Since healing is likely to occur with the tendon in a lengthened condition with subsequent dropped-finger tip, and since the joint space is always opened into by the trauma with the possibility of tags of tissue lying within the joint which may become ankylosed, operative repair of the injury is the method of treatment of choice. Exposure of the injured area is best done through an incision which does not lie directly over the line of proposed tendon and capsule suture, which does not interfere with the nail bed, and gives adequate space for suturing. This may be accomplished by an L-shaped incision over the dorsum,

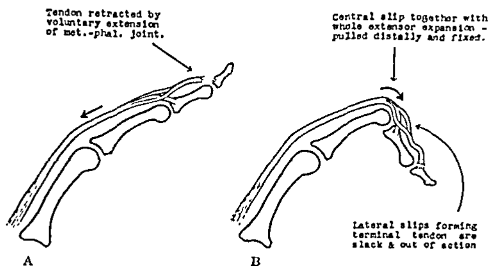


Fig. 279.—Rationale of treatment of "mallet finger." *A*, Finger immobilized in full extension at *both* interphalangeal joints The terminal part of the tendon is still subject to strain. *B*, Finger immobilized with the proximal interphalangeal joint in right-angled flexion. Terminal part of tendon is completely relaxed. (From Farquharson, E. L.: Illustrations of Surgical Treatment, Instruments and Appliances, ed. 2. Courtesy of E. & S. Livingstone, Edinburgh, Scotland)

... and extending ¾ cm. distal to ... imal to the nail bed from the distal end of the longer incision. Usually little difficulty is experienced in ... the tendons, since separation is not great due to the attachment to the ...

... e results are usually good if asepsis ..."[97]

"*Button-Hole*" *Rupture of the Extensor Tendon of the Finger.*—Forceful passive flexion of an extended finger (indirect trauma) or a blow on the first interphalangeal joint (direct violence) may cause a tear of the dorsal aponeurosis over the proximal interphalangeal joint in such a manner that

the two halves of the extensor tendon separate and displace volarward. The joint comes to lie between the two halves, and any effort at extension increases the deformity (Fig. 280). The only treatment for this condition is an operation in which the rent in the tendon is approximated, though as Mason[96] says, "full free movements can scarcely be promised."[98]

Dislocation of the Dorsal Tendons Over the Metacarpophalangeal Joints.—According to Mason,[96] this rare condition may be cured by early splinting in extension. Straus[99] believes that immobilization in extension cannot be depended upon for complete restoration. He says: "It would appear that operative repair, in which a retention sling is fashioned from the fibrous tissue just proximal to the metacarpal head, gives good functional and anatomic results. This should be combined with suture of the associated lacerations of tendon and capsule as disclosed by operation."[100]

Rupture of the Tendons of the Wrist.—This condition usually occurs after some disease, usually tuberculosis. According to Mason,[96] "The trauma which most frequently leads to spontaneous rupture is fracture of the radius." The treatment is operative repair.



Fig. 280.—"Button-hole" rupture of the extensor tendon of the little finger. (Milch, H.: Am. J. Surg. 13: 244, 1931.)

Mason[96] says the tendon of the extensor longus pollicis ruptures occasionally at the point at which it passes distally from under the dorsal carpal ligament. The rupture follows weakening of the tendon due to constant rubbing against the ligament, such as may occur in certain occupations (*e. g.*, that of the drummer). According to Platt,[101] the tendons most liable to rupture by a process of attrition are the extensor longus pollicis and the long head of the biceps. Danckelman[102] reported 7 cases of spontaneous rupture of the long extensor of the thumb. In all cases, rupture followed fracture of the radius in women between the eighth and the eleventh week after the fracture, which was barely dislocated and was usually difficult to demonstrate. The most likely cause, according to Danckelman, was an injury of the tendon at the crest of the radius due to severe stretching at the moment of the fall. This early injury gradually led to the rupture through attrition.[103] The treatment of this condition is excision of the injured portion of the tendon and the grafting of a piece of palmaris longus tendon or of an extensor tendon of the toe.[104]

Rupture and Dislocation of the Tendon of the Long Head of the Biceps.—Fievez[105] reports 22 cases of intracapsular *rupture of the tendon of the long*

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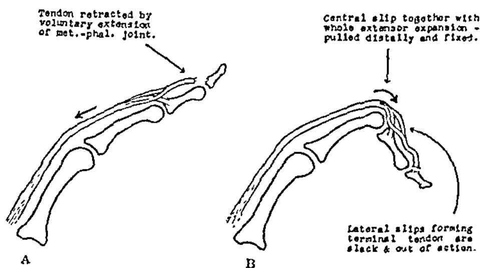


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the long limb of the L running along the posterolateral surface of the finger and extending from a point 1½ cm proximal to the distal interphalangeal joint to a point ¾ cm. distal to the joint. The short arm of the L passes transversely across the finger proximal to the nail bed from the distal end of the longer incision. Usually little difficulty is experienced in [illegible] which time move- [illegible] ...ally good if asepsis has been rigid and if healing occurs without infection."[97]

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Rupture of the tendon of insertion results from violent traumatism exerted on the arm in the position of pronation. In this position the tendon is partially rolled about the radius.

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In an important paper entitled "The Common Syndrome of Rupture, Dislocation, and Elongation of the Long Head of the Biceps Brachii," Gilcreest[106] gives full details of diagnosis and treatment. The reader is referred to this valuable contribution for a more detailed consideration of this subject.

Conwell[107] reported a case of *subcutaneous rupture of the biceps flexor cubiti* and made a review of the literature. He says:

"The symptoms and the diagnoses are best brought out by the presence of an enlargement or a swelling which varies according to the severity of the muscle rupture. Pain and history of an injury and the finding of a definite gap between the muscle substance, in most cases, make possible a positive diagnosis . . .

"The treatment is immediate exposure of the ruptured muscle, preferably with the 'hockey-stick' incision, and a complete suturing of the muscle and fascia with interrupted chromic catgut and a standard closure of the skin Fixation of the arm, forearm, and shoulder in a proper splint or dressing to prevent any motion of the elbow or shoulder joint and any strain on the biceps until healing has taken place, should always be done. The splinting is very important and, unless motion is closely watched, union in the muscle [illegible]

[illegible]

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head of the biceps without dislocation or fracture of the head of the humerus, the studies of Meyer[110] show not only its relatively common occurrence but also its threat of tendon destruction. This author says: "Uncomplicated, partial, or complete, spontaneous forward dislocation of the supratuberosital and intertuberosital portions of the tendon of the long head of the biceps, onto or over the lesser tuberosity as far as the tendon of the subscapularis is common in laborers past middle life. The dislocation may be due to gradual stretching, detachment or destruction of the capsule proximal to and in the region of the lesser tuberosity." The tendon may become divided by attrition and obtain a secondary attachment to the humeral diaphysis, or it may retract completely before becoming attached.[111]

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"In complete rupture of the supraspinatus the following conditions, symptoms and signs commonly are present within twenty-four hours: (1) The patient must be a laboring man or woman. [Codman never has seen a

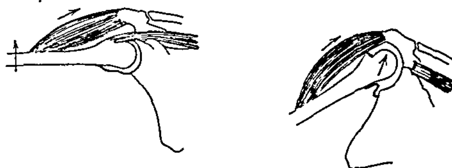


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onset and particularly when a sudden snap has occurred during a movement of abduction or when there has been a fall on the shoulder with or without dislocation." (Wilson[114])

Keyes[115] found the incidence of rupture of the tendon of the supraspinatus muscle in an unselected series of 73 cadavers to be 19.18 per cent. It occurred in persons over the age of 50 years. Henry[116] feels that many cases of undiagnosed disability of the shoulder are caused by evulsion of the supraspinatus tendon from the greater tuberosity of the humerus and that

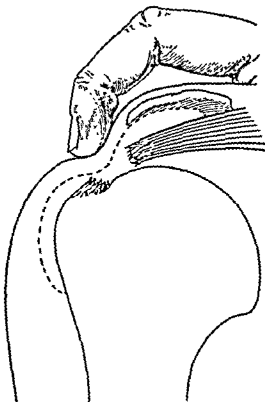


Fig. 282.—"Tip of finger pressing on eminence and on sulcus. The plane of this diagram is halfway between the coronal and sagittal. . . . It is the ability to put the finger in this position which enables one to make the clinical diagnosis of rupture of the supraspinatus tendon. The dotted line represents the contour of the bursa. The sulcus lies immediately under the tip of the finger and the eminence just external to it. Therefore, . . . the tender [illegible]

Tendon, and Other Lesions. Privately printed by E. A. Codman, 227 Beacon St., Boston, Mass., Thomas Todd Co.)

roentgen evidence should be an aid in helping to establish the proper diagnosis. Soft tissue roentgen technic with anteroposterior views with the arm in abduction and complete internal rotation reveals the site of insertion of the supraspinatus tendon in silhouette on the humerus.[117]

Haldeman and Soto-Hall[118] describe a test for rupture of the supraspinatus tendon as follows:

"In acute cases we have made it a practice to inject from 10 to 15 cc. of 1 per cent procaine hydrochloride into the subdeltoid bursa (Fig. 283). The needle is directed toward the upper border of the greater tuberosity of the humerus. As soon as the bone is struck, the needle is withdrawn one-eighth inch and an attempt is made to aspirate any fluid that may be

present in the bursa; then the procaine is injected, followed by a small amount of air. In those cases in which there is a reflex inhibition of function of the supraspinatus muscle as a result of subdeltoid bursitis or adhesions, the patient is able to abduct his arm actively a few minutes after this injection of procaine. Under the local anesthesia so produced it is possible to carry out stretching movements of the shoulder joint that have a valuable therapeutic effect. A similar benefit was observed from the injection of procaine into calcified subdeltoid bursae. These often show a disappearance of the calcium deposits within a few days, and the patient's subjective symptoms also disappear. In such cases no other type of treatment is required, although we sometimes repeat the injection. If no improvement in the active abduction of the shoulder results from this injection, the diagnosis of tear of the supraspinatus tendon is made certain.

These authors add: "When a diagnosis of tear of the supraspinatus tendon has been made, the treatment will depend on the completeness of the tear. The use of an abduction

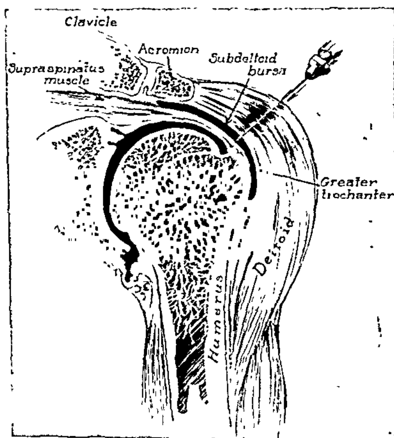


Fig. 283.—Frontal section of the shoulder region, to show the point of insertion of the needle for the purpose of anesthetizing the subdeltoid bursa as a diagnostic and therapeutic procedure. (Haldeman, K. O., and Soto-Hall, R.: J. A. M. A. 104: 2319, 1935.)

splint for from four to six weeks, followed by physical therapy, will suffice in cases of partial tear. A complete tear should be repaired surgically as soon as its diagnosis is made, because much harm will result from delay."

Codman states further: "The pain often is very severe for a week. The acute pain then wears off but exertion causes intense discomfort over a period of several months, or even years. During the first few months the patient may even continue at work, particularly at bench work where he does not have to raise the arms, but the suffering continues, and work becomes impossible. . . . In these cases physiotherapy gives only temporary relief but proper surgical measures restore them to normal. Before attempting operative procedures

much work should be done on cadavers so that the anatomy of the parts will be thoroughly understood."[117, 119]

Calcification of the supraspinatus tendon (a calcium deposit in the tendon) may be a cause of painful shoulder. An accurate x-ray examination is important in the diagnosis. The best treatment in the acute stage is excision of the deposit; and this is probably also the case in the chronic stage.[120]

McLaughlin[121] has supplied a valuable guide to the differential diagnosis of the lesions of the musculotendinous cuff of the shoulder. Students are referred to his important paper. He says:

> maintained the signs but eventually lost most of the symptoms of the lesion. Almost all have been adequately followed, and it has been apparent that, while such subsided lesions may produce occasional mild symptoms related to weather or overuse, no disabling exacerbations of pain are liable to occur unless the shoulder is subjected to another injury.
>
> "The only definite indication for operation consists of pain or disability sufficient in duration or severity to make the procedure worth while from the patient's point of view. This indication may exist in the presence or absence of a clearcut diagnostic picture. Even in the absence of definite signs the diagnosis of internal derangement of the shoulder joint may be made and, as in the case of the knee joint, warrants exploration and eradication of existing pathologic conditions."

In discussing calcification of the tendon cuff of the shoulder, Howorth[122] says:

> "Successful aspiration, irrigation, or puncture, is simple, safe and effective, not only in relieving pain, but also in removing the calcareous material, and the results, immediate and late, are good. Operative drainage of the calcified cavity in the tendon offers the surest and most permanent relief of any type of treatment, and is often the best or only method of

Traumatic subluxation of the long head of the biceps brachii has been reported by Lieberman.[124]

Subclavicular dislocation of the omohyoid muscle due to rupture of its binding fascia has been reported by Wenger.[125]

> frequently involved are the supraspinatus, rectus abdominis, extensors of the fingers and thumb, adductors of the thigh and triceps brachii If all the so-called sprains and bruises and other injuries could be exposed at operation it is possible that many other muscles would be found to be the site of either partial or complete rupture. . . . Ruptures of muscles and tendons are common injuries. They occur most frequently in middle-aged individuals who are physically active but in whom age has begun to weaken the stress and strain which the tissues can tolerate. Disease plays a definite part in the causation but is not a necessary prerequisite by any means.
>
> "These injuries are frequently neglected by the patients themselves as well as by the
>
> sutured while partial ruptures may usually be treated by immobilization. The treatment, however, in any case must be individualized."

Tenosynovitis of the Long Head of the Biceps Humeri.—Schrager[127] believes that tenosynovitis of the long head of the biceps is a definite clinical entity. The subjective pain may be diffuse, but the objective pain is always located in the bicipital groove. The condition may be acute, subacute or chronic. There is marked loss of function of the shoulder in the acute condition, with less in the others.

"Much benefit and occasionally instant cure can be obtained by sudden traction upon the arm and shoulder while the arm is relaxed and in a position of abduction. The rationale of this treatment is based upon the supposition that the tendon does not fit properly in the groove and that the maneuver makes a satisfactory replacement in the groove. One may argue that since the biceps tendon fits snugly in the bicipital groove, it is difficult to conceive its displacement out of the groove. Sumner L. Koch, commenting on the sudden relief of pain by sudden traction upon the arm in abduction, states: 'I am wondering if this may not be due to the tearing of adventitious adhesions rather than replacement of the tendon in its groove.'" (Schrager) Rest and diathermy are valuable in the treatment.

Traumatic Synovitis.—Contusions of joints, sprains, ruptured ligaments and fractures may be the cause of traumatic synovitis. The reaction of the synovia to the injury is the production of an excessive amount of synovial fluid. According to McWilliams,[87] the synovial membranes have no stomas, and hence are capable of but very slow absorption of fluid or blood. The acute distention of the joint causes great pain, especially upon moving. In the treatment of this condition some surgeons advise repeated aspiration and early mobilization by means of active rather than passive movements. The aspirations are carried out in the manner previously described under sprains. In this condition there is an inflammation of the tendons and sheaths which is nonmicrobic in character. The repeated small injuries caused by overuse of a gliding mechanism will cause it to become inflamed and painful when in motion. A strenuous game of tennis without previous toughening or exercise may cause traumatic synovitis of the tendon sheaths in the neighborhood of the wrist. The synovia are red, and there may be some external swelling. The area will be locally tender, and pain will be elicited by all motions of the hand which involve the sliding back and forth of the tendons in the sheaths, particularly when under tension. Palpation of the affected area during the performance of motion may disclose a sensation of fine crepitus caused by the rubbing together of the inflamed surfaces of the tendon in the inflamed sheath. Overuse of the wrist or elbow joint may bring about a similar condition, with increased effusion of joint fluid, causing pain. Overuse of the shoulder joint may cause traumatic tenosynovitis of the tendon of the long head of the biceps. The usual treatment of tenosynovitis is *immobilization* of the affected part until the pain subsides. When the tendon sheaths in the neighborhood of the wrist are involved, a padded wood splint will be bandaged to the upper surface of the forearm and hand. In the case of the shoulder the immobilization of the arm in a sling may suffice. A Velpeau bandage may be necessary, however. The patient should not resume exercise of the affected part until all tenderness on pressure and all pain induced by motion have completely subsided. The exercise will then be cautiously resumed. Recovery is hastened by the application of heat, by means of diathermy, radiant heat, hot fomentations, an electric pad, etc. Lipscomb[128] says: "Roentgen therapy also is widely advocated in the treatment of simple tenosynovitis or tendovaginitis crepitans. Herrnheiser[129]

especially recommended roentgen therapy in small doses for the more acute phases. Oftentimes he used no fixation and cited as advantages this and the fact that a cure is effected in the same, or possibly shorter time than with the usual fixation treatment. The patient was often allowed by Herrnheiser to work moderately with the injured extremity during the period of treatment." Lipscomb concludes: "Treatment should be conservative for two months, then if improvement has not occurred surgical procedures are indicated. Either incision or excision of the sheath, whichever is indicated, offers the best chance of cure. Roentgen therapy combined with splinting is the conservative method of treatment that offers the best results." Syphilis of the tendon of the long head of the biceps muscle has been reported by Schrager.[130]

Bursitis.—Bursae are small sacs lined with synovial membrane. They are situated in the neighborhood of joints where tendons press upon bones or the joint capsule, or they may be found between the skin and superficially situated bones. Certain bursae are constant, and others are present only when there is prolonged irritation. There are perhaps a thousand bursae present in the human body, and they act between the moving parts as a sort of lubricating buffer. The synovial membrane of the bursal sac may become inflamed from overuse or, possibly, from a low grade infection secondary to a distant focus of infection, such as an abscessed tooth, infected tonsil or the like. Inflammation of the bursa will cause pain when any motion is made which causes the surfaces to rub together. This pain may be so severe as completely to incapacitate the motion of the affected parts. There will often be marked tenderness to pressure of the affected bursa. In advanced cases, particularly in subdeltoid bursitis, a deposition of calcium salts will take place and a calcified bursa will result. According to Carnett,[131] careful observation has shown that the calcareous deposits are usually extrabursal. By the term "exostosis bursata" is meant a benign tumor that arises from the epiphysial portion of the bone. It consists of bone and cartilaginous tissue covered by a connective tissue capsule.[132] In cases of chronic bursitis with excessive fluid caused by low grade pyogenic infection, trauma or tuberculosis, small foreign bodies, termed "rice bodies," may be found in the bursa. Their origin has been carefully studied by Mumford.[133] Kuhns[134] says: "Adventitious bursas are frequently observed in subcutaneous tissues that are subjected to repeated pressure and friction." When spontaneous disappearance does not take place, surgical removal will be indicated.

Acute bursitis is extremely disabling, and unless prompt and proper treatment is instituted, the ailment may be prolonged into a chronic bursitis. [illegible] have been recommended. The immobilization should be continued until the pain and tenderness have practically disappeared, when very restricted active motion and massage are actually started.

Acromial Bursitis.—Inflammations of the acromial bursae are acute or chronic and are generally caused by trauma. The chronic type is caused by repeated traumatisms following upon carrying a hard object upon the shoulder, *e. g.*, hod carrying. There is a circumscribed, fluctuating swelling over the acromion which usually is painless. (McWilliams) The condition

generally will quickly yield to the removal of the traumatism, the application of heat or cold and the institution of rest. Repeated aspirations are of use, and the infected area must be thoroughly drained.

Subdeltoid Bursitis (*Subacromial Bursitis*).—The subdeltoid bursa facilitates the movement of the head of the humerus beneath the deltoid muscle. These types of subdeltoid bursitis are described: the traumatic, those due to focal infection, and the suppurative. Rogers[135] differentiates three varieties: "(1) the acute type which comes on rather suddenly; (2) the chronic adhesive type with slow onset, the so-called 'periarthritis' of the shoulder or the 'frozen shoulder,' which may end in an absolute loss of abduction and rotation; and (3) the traumatic type, which has a history of slight trauma as a cause." Rogers[136] says there is no evidence that there is an element of focal infection. This ailment may follow excessive overuse of the shoulder joint. It may come about following a short period of overuse or as a consequence of long-continued exercise, as in persons who have to hold the arm abducted for long periods (dentists and artists).

Rubert[137] says: "The most common clinical findings in the 288 cases were: (1) pain in all, (2) restriction of motion in 95 per cent, (3) a pressure point over the greater tuberosity in 58 per cent and (4) muscular atrophy in 20 per cent. Roentgen examination in 154 cases showed atrophy of the proximal end of the humerus in 22 per cent, calcification in the region of the bursa in 18 per cent and local arthritic changes in 10 per cent.

"Radiation of the pain to the insertion of the deltoid muscle, to the cervical region, and down the arm to the wrist and hand was present in 15 per cent of cases. Of the 95 per cent of patients with restriction of motion, 35 per cent had restriction of abduction alone, 28 per cent had restriction of abduction plus restriction of external rotation, and 26 per cent had restriction of all motion. Restriction of the other motions accounted for the remaining 10 per cent."

There may be tender swelling just below and in front of the tip of the acromion process.

In the *treatment of acute subdeltoid bursitis* the needling method of Alanson Weeks[138] is an important contribution. In 40 cases he has produced immediate relief by the simple "relief of tension afforded by puncturing the firm-walled sac in numerous places with a needle." Weeks[139] says: "I venture to say that every patient suffering from subdeltoid bursitis of the acute type, whether the sac contains calcium or not, will be relieved at once if the tension is removed by numerous punctures with a fair-sized needle, whether local anesthesia with procaine hydrochloride only or general anesthesia is used. Chronic conditions also will be relieved and the calcium absorbed after use of the same method, unless the salt has organized into bony hardness, in which case surgical removal is justified." The puncturing may be done with local anesthesia, but this may be somewhat painful. With vinethene, ethylene or nitrous oxide anesthesia, fanwise needling of the bursa in all directions is usually the best procedure. Weeks has obtained relief on aspiration of 1 cc. of straw-colored fluid.

Patterson and Darrach[140] used needling and irrigation in 63 cases of subdeltoid bursitis. Their technic is as follows: "With the hypodermic needle and procaine hydrochloride a small wheal is made in the skin over the point of maximal tenderness. The skin is nicked through the epidermis. In like manner [illegible]
posterior to the greater tuberosity [illegible]
ing the injection of the procaine [illegible]
through the cutaneous incision in the anterior portion of the anesthetized region. The point of the needle is directed posteriorly and upward toward the under surface of the acromial

process of the scapula. The needle is then pushed deeper and, after it has reached a depth of from one-half to three-fourths inch, the wall of the bursa can be felt as a definite resistance. A quick stab places the point of the needle within the bursa.

"Following the placing of this anterior needle, a second one is inserted into the region just posterior to the greater tuberosity, about one fingerbreadth below the acromioclavicular joint. The needle is pushed gently down to the superior facet of the greater tuberosity and actualbone is felt with the tip of the needle. Then the needle is slowly withdrawn for about one-e ghth inch and the tip of the needle is pointed in the direction of the assumed position of thei tip of the anterior needle which is in the bursa. After this needle has been inserted for about one-half inch, the bursa is entered and 2 cc of procaine hydrochloride is used in each of the needles on the way down to the bursa and on going through the bursal sac. As soon as the two needles are in place, the syringe is filled with physiologic solution of sodium chloride and this is pushed through one needle to flow out the other. Usually, as soon as one syringe of saline solution has been pushed through, the patient states that the

out pain. As little saline solution as possible should be allowed to exude into the surrounding tissues. If this is prevented, the patient's arm will not be sore the following day. After the irrigation the arm is placed in a sling and the patient is allowed to go home and told to use the arm and move it only when he feels like it. No haste is made, with the result that on about the fourth to the sixth day the patient has full use of the arm without pain. Irrigation was most successful in acute cases without history of previous attacks, in cases in which the calcium, as seen in the roentgenogram, was not dense, round or bonelike and in cases in which the acute pain was localized and did not radiate."

Kaplan and Hawkins[141] say: "For the past year, on the orthopedic service of the Station

and the skin over the area is infiltrated with 1 per cent novocain. The infiltration is carried down to the cortex of the head of the humerus. With the needle in place its position is checked either by the fluoroscope or by *x*-ray plates to make certain the needle is in or near the calcified deposit. This is most important. Failure to do so, and doing the procedure blindly, is the cause of many failures. . . After adequate analgesia has been obtained and with the point of the needle in or about the deposit, the point of the needle is withdrawn 2 or 3 mm., and an attempt is made to aspirate calcareous material." This is usually not successful, and the writers have come to the conclusion that aspiration and washing out of the bursa is not necessary, as repeated postoperative roentgenograms made at regular intervals will show the gradual disappearance of the deposit within several weeks. "With the needle in place, 30 to 50 cc. of warm saline solution are slowly infiltrated into and close around the deposit, at the same time numerous punctures are made into the bursa "

An older method of treatment of acute subdeltoid bursitis is to bandage the arm to the chest wall by means of a Velpeau bandage, with a soft axillary cotton pack, and to apply heat externally to the shoulder. Aspirin or, if necessary, codeine will be exhibited. The arm will be immobilized until the pain and tenderness have greatly diminished. Moist heat will be helpful. *This may be necessary for from three to fourteen days. The bandage is then* removed and a sling substituted. Diathermy and skillful, gentle massage at this juncture may be very valuable. Hitzrot[142] says diathermy is painful and prefers hot moist dressings in the early cases and an electric pad or hot light in the late cases. As the pain and tenderness continue to subside, increased active motion is permitted. Surgical drainage gives immediate relief in acute cases.[135] In describing the drainage of a subdeltoid bursa, Kaplan and Ferguson[143] say:

With this relief of tension there is an almost immediate subsidence of pain. The calcified material which escapes is removed, but no effort is made to completely evacuate the area of calcification. The wound is closed with interrupted sutures. The arm is immobilized with an axillary pad and sling. If appropriate sedative drugs are supplied for the first twenty-four hours, the patient experiences little difficulty and the whole procedure may be carried out without hospitalization. In about a week, most of the cases have regained full range of motion without pain." Rubert found that "conservative measures, including physical therapy, the use of an abduction splint and manipulation, gave good results in 69 per cent of 168 cases, improvement in 19 per cent and poor results in 12 per cent. Operation in 21 cases resulted in cure in 10, or 48 per cent; improvement in 5, or 24 per cent, and no improvement in 6, or 28 per cent."[144]

In conditions which do not yield to treatment in a short time, it may be wise to immobilize the shoulder with the arm in 90 degree abduction by means of an aeroplane splint. This will relax the tension of the deltoid muscle and remove some of the pressure upon the bursa. Papurt[145] maintains abduction by strapping a leather wristlet to the top of a tight-fitting cap. In some cases the recumbent treatment with traction upon the humerus will be advisable. In the milder chronic cases skillful stretching, as described by Gordon,[146] will be valuable. Cooperman[147] says that experience has shown that conservative measures supersede surgical procedures. Spontaneous recovery occurs even in the calcific variety of the affection.

Carnett[148] analyzes 44 cases, in 19 of which operation was performed. In all of this author's cases the pain was relieved at once by the operation. In the chronic cases it ceased after from one to several weeks. The operation used by Carnett is as follows:

The incision is made from the acromial process downward 2 or 3 inches toward the deltoid insertion and across the greater tuberosity. The deltoid fibers are split to expose the roof of the acromial bursa. The bursal sac is then carefully opened and explored with a curved hemostat or the finger, aided by manipulation of the arm. In some cases the breaking up of adhesions is necessary. The deposit can be seen upon the floor of the bursa as a grayish substance. The bursal floor is incised and the deposit removed with a curet. In the more [illegible]

Harris'[149] report is striking testimony of the value of diathermy in the treatment of subdeltoid bursitis, even when calcification is present. His patient had had intermittent attacks for seven years. After two weeks' treatment he resumed the playing of a bass viol, and after 32 treatments all pain and restricted motion disappeared. Of great interest is the actual absorption of the calcified deposit, as shown by the *x*-ray. Mumford and Martin[150] studied the calcified deposits in subdeltoid bursitis and concluded that the etiologic factor is not definite. "Repeated mild trauma with the arm in the abducted *position may play an* important part in the production of the lesion or it may be a single mild or severe single trauma leading to an *injury to the tendons*. . . . The calcareous deposit has no relation to the pain other than that perhaps it may lead to further trauma and produce an acute attack. It has been found in shoulders free from pain and it will persist in the roentgenogram even after the acute sysmptoms have *disappeared*. . . . Surgical intervention should never be advised until diathermy has been used. All our patients became well by this conservative form of treatment and in all cases with a deposit shadow the deposit either entirely disappeared or became much smaller and less dense in the roentgenogram. In none was surgery necessary. The average number of treatments was 21, given daily for the first two weeks [illegible]

[illegible] or both. As a rule the most severe pain is located over the outer aspect of the lower part of the deltoid muscle, and an area of tenderness is found at a point just beneath the anterior edge of the acromion process.

Grossman[152] advises that when adhesions have formed in the bursa, the arm should be manipulated under anesthesia and held fully extended for a day or two, with external heat. In the cases of severe chronic bursitis with calcification of the bursa, open operation with incision of the bursa will be indicated. The stooping exercises for shoulder lesions (Codman) are valuable (Fig. 284).

Lapidus[153] believes that infiltration with novocain is a valuable measure in the treatment of painful acute tendinitis at the shoulder joint. His technic is as follows:

"The present day infiltration technique used by the author is as follows: The tender spot is infiltrated with 10 to 20 cubic centimeters of 1 per cent novocain solution. The point of the needle is inserted close to the cortex of the head of the humerus and then withdrawn 3 or 4 millimeters. Control roentgenograms are taken with the needle *in situ* to make certain that its point is in the deposit. After adequate analgesia has been obtained, 30 to 60 or

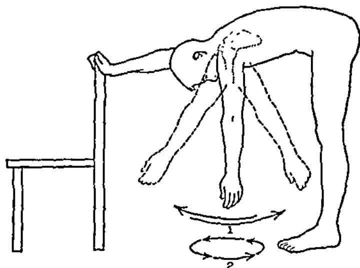


Fig. 284.—Stooping exercises for shoulder lesions (after Codman). The patient bends forward, grasping a chair with the hand of the sound arm; the painful arm falls forward of its own weight to become perpendicular to the floor. In this position, the patient is asked

Lippincott Co., 1942.)

more cubic centimeters of warm normal saline solution are slowly infiltrated into, and

2 or 3 days. The patient is encouraged to practice stooping exercises and to limber up the shoulder in a warm bath. Adequate sedatives are administered the first few days if necessary. After the initial postoperative aggravation of pain, relief is obtained, as a rule, within a few to 48 hours; in a few cases immediate relief occurs without any initial increase of pain, and in a few the pain persists for 3 to 4 days. At first, the mobility of the shoulder is impaired, but motion is restored within 2 or 3 days to 2 weeks, and the patient is able to resume his work."

Shoulder Pain.— The causes of shoulder pain include a wide variety of conditions, and they should be included in a consideration of the differential diagnosis of subdeltoid and acromial bursitis. These causes are discussed by Butler and Elward[155] chiefly from the standpoint of the lesions demonstrable by the x-ray. In abstract, their paper is as follows:

According to French's "Index to Differential Diagnosis," the direct causes of shoulder pain include injury, arthritis, synovitis, fibrositis, myositis, neuritis, bursitis and local paralysis. Indirect causes of shoulder pain are angina pectoris; aneurysm; pleural, pulmonary and mediastinal conditions; gastric lesions; duodenal lesions; cervical rib; hepatic lesions; nerve lesions; tumor of the neck; spinal tumor; gliosis, and neuroma.

Other causes that have been suggested are pulmonary infarct, actinomycosis of lung, subphrenic abscess, perisplenitis, acute pancreatitis, suprarenal tumor, tumor of the hypophysis, apical tuberculosis and hypertrophic arthritis of the cervical vertebrae, usually occurring in the lower four bodies and causing irritation of the brachial plexus. Calcified cervical glands (healed tuberculous glands) also may cause such irritation. They need not be large to affect the nerves.

Clavicular spurs are usually near the outer end and underneath. They may result from periosteal injury or may be congenital. They also cause nerve irritation. Thompson and McLaughlin[156] describe a case of "acute shoulder pain incident to the presence of *calcified deposits in the tendon of the subscapularis muscles*. . . . Surgical removal of the deposit resulted in the prompt relief of pain and complete return of function."

A calcified deltoid bursa should be called an "opaque" deltoid bursa because calcium is not always present. The opacity may disappear on the application of heat or electrotherapy.

The explanation given for shoulder pain arising from lesions in the neighborhood of the diaphragm is that the phrenic nerve has its origin near that of the brachial plexus which supplies the shoulder.

Many of the conditions enumerated may be demonstrated roentgenographically. A 10 by 12 inch film will cover the shoulder, cervical region, clavicle, upper part of the thorax and mediastinum. The demonstrable lesions are cervical caries, cervical rib, cervical arthritis, calcified glands, clavicular spur, opaque bursa, aortic aneurysm, apical tuberculosis, apical neoplasm, mediastinal new growth, Hodgkin's disease and injuries or lesions in the shoulder itself.[157] (See also Rupture of the Supraspinatus Tendon.)

Manipulative Treatment of the Stiff Shoulder.—In an important paper on this subject, Ellis[158] quotes Sir Robert Jones as follows: "Let me emphasize the statement that there is nothing which the manipulator (osteopath) does which cannot be more safely undertaken by any practitioner (of medicine) who possesses a knowledge of the pathology and elementary anatomy of the joint, but he must become familiar with the methods of manipulation which are safe and thorough—let it be fully realized that there are no hidden or mystic rites in any 'bone setting.'" Shimberg[159] believes the injection of amniotic fluid concentrate to be valuable after the manipulation of stiff joints under anesthesia.

Ellis[158] says: "Manipulation is definitely contraindicated in: (1) Tuberculosis of the shoulder joint. (2) Syphilitic and parasyphilitic articular or

periarticular lesions. (3) A tendency to myositis ossificans. (4) Gonorrheal affections. (5) Cervical neuritis and radiculitis."

The conditions in which manipulation is indicated fall into four groups (Ellis): "(1) The frankly post traumatic. (2) 'Periarticular' conditions where trauma plays a rôle of varying importance. (3) Post rheumatic conditions. (4) Osteoarthritis."

Ellis[158] gives the technic of graded manipulation as follows·

"By manipulation of the shoulder joint followed by maintenance of the joint in a position of rest and muscle balance, the following physiological results are obtained:

"Relief of muscular spasm by the new position.

"Increased circulation in periarticular structures.

"Increased absorption of exudate from bursae and the joint by—

"Breaking up intra-articular and intra-bursal bands and pockets.

"Preliminary preparation or treatment can be divided into remote and immediate. By the first is meant a thorough course of baking and massage to promote circulation and relieve edema and fibrosis as much as is possible by this conservative treatment. This procedure leaves the examiner able to ascertain exactly which movements are persistently painful and restricted. He should make written notes of the exact degree of passive and active abduction, internal and external rotation possible at this time to check with his findings as to movement when the patient is anaesthetized for manipulation. This conservative treatment should be continued until no further progression in improvement occurs.

"Immediate preparation consists of the application of hot, moist dressings with the shoulder in the greatest possible abduction the patient can endure for four to six hours

"At the first manipulation under gas (preferably ethylene) only one motion can be attempted. When the operator, who has slowly attained a slight improvement of motion by weeks of baking and massage, finds he can accomplish all movements by force, after the patient is anesthetized, he sometimes feels an almost irresistible impulse to pump the arm up and down and rotate it forcibly in all directions until passive motion is complete. This is often possible but has calamitous results A more complete spasm ensues, ruptured fibrinous adhesions are replaced by fibrous bands and the loss of function is greater than before the treatment. Kneading of the structures which feel tense should accompany the manipulations When spasm in a muscle still persists, if the part is held immobile and 'on the stretch' for two or three minutes, the spasm will quite surprisingly relax and further motion can be accomplished

"The one motion attempted at the first maneuver should be abduction and this by a 'coaxing' motion and only until one noticeable tearing of shortened structures is felt or heard. This snap which the osteopath calls 'reduction of a subluxation' may be due to stretching of a folded joint plica, release of a fibrous shortened tendon or ligament or tearing of an intra-articular or bursal band. Stop here and apply hot dressings with the

often proportional to the motion permitted in the joint; that they depend on function

excessive. On awakening in the morning the stiffness is greater than it is later in the day after even minimal use If manipulation has been properly performed one rarely finds the

humeral abduction. After another waiting period, secure complete external rotation in

massage. In the author's experience, the motions of extension (or retraction) and flexion (or protraction) will be secured without special manipulation or after treatment if complete rotation and abduction are re-established."[160]

Olecranon Bursitis.—Inflammation of the olecranon bursa commonly occurs from the traumatism of resting the olecranon process on a hard surface. Lasher and Mathewson,[161] who made a study of 15 cases, describe 3 distinct bursae in the region of the olecranon as follows:

1. "A large subcutaneous bursa lying directly beneath the skin, which when fully distended, measures about 2½ inches in length, ¾ inch in width, and is of varying thickness, with the upper half lying above the tip of the bone and the remaining portion firmly attached to the underlying periosteum.

2. "A small bursa which is not easily demonstrable within the tendinous attachments of the triceps.

3. "A slightly larger bursa underneath the tendinous insertion of this muscle."

The bursa over the olecranon process will become swollen, red and tender. Minute superficial abrasions or the wounds incurred by aspiration may provide the portal of infection for the bursa. Rest, the avoidance of pressure on the olecranon process and the application of heat will generally remedy the milder forms of this ailment. The application of a pressure pad has been recommended by some, but its usefulness is questionable. According to Lasher and Mathewson, [161] acute infection of the olecranon bursa demands an early operation with complete removal, and if an operation is not performed, osteomyelitis of the underlying bone is a most frequent complication. Lasher and Mathewson advise a 2 inch longitudinal incision which is slightly elliptic, so as not to leave a scar directly over the olecranon. The curve of the ellipse should be toward the radial side. Because of the difficulty in separating the attached portion of the bursa without opening the periosteum, these authors advise that this small area be curetted and phenolized in order to destroy any secreting cells and to remove completely the infected tissues. The wound is closed without drainage. After operation a snug bandage is applied with pressure over the bursal site to prevent reaccumulation of fluid. Motion is instituted at once. McWilliams advises early aspiration and the employment of a compressive bandage. He advises operation in the chronic or infected forms. In the latter, after "scraping the wall" of the bursa, drainage is employed. In the more chronic forms excision of the bursa will be required. The bursa is superficial and can readily be excised under local anesthesia.

"Tennis Elbow," Epicondylitis Humeri, Radiohumeral Bursitis, Epicondylitis, Epicondylalgia, "Golf Elbow."—The excessive supination and pronation incident to a strenuous game of golf and certain other activities may bring about inflammation of the bursa at the radiohumeral articulation. A tender point may be felt over the head of the radius or external condyle of the humerus, and supination and pronation will elicit pain in this area. There may be weakness on attempting to lift relatively light objects. According to McWilliams, the essential pathologic feature is believed to be "an inflammatory reaction in a commonly existing bursa, varying in size, and located beneath the conjoined tendon of the extensor muscles between this tendon and the tip of the epicondyle, the origin of the supinator radii brevis muscle, and the radiohumeral joint." It is said to begin with involvement of the extensor muscles.[162] North[163] says:

"The lesion has been variously supposed to be a [illegible]

[illegible]

the majority."

Cyriax[164] says: "The evidence is overwhelmingly in favor of a typical tennis elbow's [illegible]

[illegible]

perios[illegible]

reaso[illegible]

dylar [illegible]

of causing the symptoms of a tennis elbow."

Hansson and Horwich[165] made a very careful study of epicondylitis humeri and conclude that it exists in two forms: "One acute form, such as is seen in the tennis elbow, and one chronic form, which is usually occupational." They believe that the pathologic condition is probably that of "periosteal avulsion with myofascitis. In the real tennis elbow the periosteal symptoms predominate, while in the occupational type the myositis is worse." Immobilization in a sling and external heat will cure the milder types. The more severe ones will require complete immobilization of the arm, forearm, and hand in a plaster cast for six weeks. A window may be profitably cut in the cast over the bursa so that the overlying skin can be painted with tincture of iodine and other counterirritants. Hansson and Horwich[165] based their therapeutics of epicondylitis on physiologic rest. By rest they mean "immobilization of the external epicondyle and the muscles originating from this bony ridge." For this purpose the authors use a cock-up splint. The writer thoroughly approves of the cock-up splint but believes that it should be extended well above the elbow to eliminate thoroughly supination and pronation.

In regard to the manipulative treatment of tennis elbow, Watson-Jones[166] says:

"The manipulation described by Mills[167] is to extend the elbow fully while the forearm is held pronated and the wrist and fingers flexed A more generally successful manipulation is that practised by bonesetters, who in the past appear to have been more successful than qualified surgeons in treating tennis elbow.[168] The elbow is held fully extended with one hand over the inner side of the joint and the other hand over the outer side of the lower [illegible]

[illegible]

relief is complete."

Cyriax[164] uses the following method of treatment of tennis elbow: "This has the merit of being simple and quick, and it does not necessitate an anesthetic. It is equally applicable [illegible]

arm on the arm with a sharp jerk toward a position of cubitus varus. A crack is usually heard, which is sometimes also obtainable from the other elbow, but the manipulation is just as effective if no sound is heard. There are no muscles capable of opposing this move-
which in any case is slight.
on are repeated thrice weekly
s is another argument against
ithout it. After this treatment
n improves to far beyond the
original state. In the writer's series an average of four treatments was enough to give complete relief, with extremes of one and nine. *The offending work or play was resumed as*
it is difficult to ascribe
s cause is proved. In general, an involved conjoined tendon at the epicondyle or its movement or strain in the presence of an inflamed structure or structures in close proximity may produce tennis elbow. The nearby structures that may become inflamed are the radiohumeral bursa, the

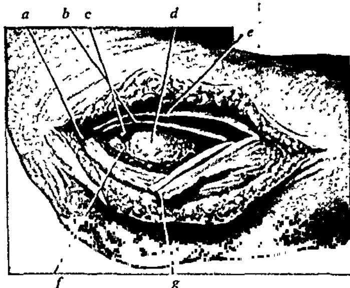


Fig. 285.—Drawing of a dissection showing the radiohumeral bursa in relation to the

1932.)

epicondyle, the conjoined tendon at the epicondyle, the capsule of the elbow joint, the radiohumeral joint and the radial nerve.

Carp states that the radiohumeral bursa exists probably adventitiously (Fig. 285). He has seen it at the dissecting table. It is difficult to discover it in a routine dissection. It lies beneath the conjoined tendon, just below the epicondyle and over the radiohumeral joint. Normally it measures about 1 by 0.5 cm., and its walls are very thin and friable. It may
1 to con-
d by the
extends
over the head of the radius. The author presents clinical, roentgenologic, therapeutic, and pathologic evidence to show that involvement of the radiohumeral bursa may produce tennis elbow.

Prompt relief may be expected from rupture of the bursa by firm digital pressure applied over the epicondyle and radiohumeral joint. When this procedure is very painful the induc-

He says: "The usual history is that, following a cut, abrasion or scratch on the dorsum of

one of the finger joints, the small wound heals. A latent period of from three to twenty days is followed by increasing soreness of the joint, swelling, redness, and tenderness. The wound may reopen and drain pus or the inflamed bursa may rupture and drain beside the healed scar. With rupture, relief of symptoms lasts only a few days. Healing, reappearance of inflammatory signs occur, and the cycle is repeated. With added new trauma, local cellulitis, lymphangitis, and adenitis may appear. The bursitis is recognized by swelling of the dorsal surface of the joint, tenderness only on the dorsum, not on the lateral or palmar surfaces, and pain on flexion which limits the motion of the finger. If one unroofs the bursa with a sharp scalpel, leaving only the floor and shallow walls, prompt healing takes place. In cases recognized early or in more acute infections developing before the wound lips are healed firmly, spreading the original wound wide apart and keeping it open allows healing by secondary intention in a short time."

Dislocations Involving the Upper Extremity.—*Dislocation of the Shoulder (Humerus).*—Because of the relative insufficiency of bone support and because of its exposed position the shoulder joint is very frequently subject to dislocation, 40 to 65 per cent of all dislocations in the body. It occurs most frequently in muscular young adults as a result of falling on the hand or elbow with the arm abducted or externally rotated, as in trying to protect oneself in a backward fall. "The weight of the body is transmitted to the head of the humerus, driving it downward and forward against the lax weak portion of the capsule of the joint."[171] The anterior inferior portion of the joint capsule is the weakest point. Dislocation of the shoulder always involves a rent in the capsule. Anterior dislocation is much more common than posterior dislocation, because of the stronger posterior muscles.

The diagnosis of the different varieties of dislocation of the shoulder is aided by a consideration of the following table compiled by Pick.[172]

Type.	Direction of the axis of the limb.	Alteration in the length of the limb.	Presence of the head of the bone in new situation.
Subcoracoid.	The elbow is carried backward and slightly away from the side.	Very slight lengthening.	The head of the bone cannot easily be felt; it is found at the upper and inner part of the axilla.
Subglenoid.	The elbow is carried away from the trunk and slightly backward.	Very considerable lengthening.	The head of the bone can easily be felt in the axilla.
Subspinous.	The elbow is raised from the side and carried forward.	Lengthening intermediate in degree between the subglenoid and the subcoracoid.	The head of the bone can be felt and be grasped beneath the spine of the scapula.
Subclavicular.	The elbow is carried outward and backward.	Shortening.	The head of the bone can readily be seen and be felt beneath the clavicle.

Other rare types of dislocation have been described. Bilateral dislocation has been reported.[173]

Dislocation of the shoulder may be accompanied by fracture of the greater tuberosity of the humerus (Figs. 286, 287), fracture of the surgical neck of the humerus or fracture of the body of the scapula. Murray[174] says: "The tendency to regard the lesion as a displacement of the head of the humerus from the glenoid, and therefore the treatment as essentially the replacement

of the displaced head, militates against the proper care of the case. The proper conception of the lesion as an injury to the shoulder region in which muscle, nerve, capsule, and vascular damage are present as an essential part of the picture, with a consequent grievous disturbance of function in addition



Fig. 286 —Dislocation of the shoulder with fracture of the greater tuberosity of the humerus

to the displacement of the humeral head, tends, on the other hand, to lead to proper treatment." The diagnosis is readily made by inspection and palpation and from the history of a fall or muscular violence. It is important to remember that a fracture of the surgical neck of the humerus may resemble a dis-



Fig. 287.—Reduction of [illegible] Note the reposi[illegible] greater tuberosity of the humerus.

location, and one should be cautioned against ill advised and dangerous attempts to reduce what is thought to be a dislocation of the humerus when, in reality, it is a fracture. When feasible, it is advantageous to make an x-ray examination before starting treatment. Holzer[176] reports a case of local



Fig. 288.—Sketch showing the position of the arm in dislocation of the shoulder.

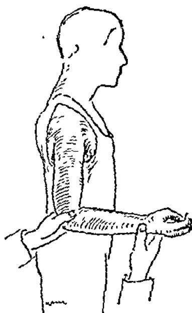


Fig. 289.—Kocher maneuver for dislocation of the shoulder. First step: The elbow is very slowly and gently brought close to the side and very slightly posterior to the midaxillary line.

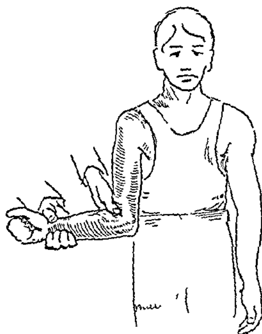


Fig. 290.—Kocher maneuver for dislocation of the shoulder. Second step: The elbow is held fixed and the forearm is slowly and gently rotated outward.



Fig. 291.—Kocher maneuver for dislocation of the shoulder. Third step: Keeping the forearm externally rotated the elbow is lifted slowly upward. Fourth step: The forearm is quickly rotated inwardly.

hemorrhage and death a few hours after reduction of a dislocated shoulder. Thompson[177] reports paralysis of the serratus anterior muscle complicating

dislocation of the shoulder. Rixford[178] says: "The careful surgeon will always assure himself, before instituting treatment, that the nerves and blood vessels are intact."

Forward dislocations of the shoulder joint generally may be reduced by the Kocher maneuver (Figs. 288-291). The successful accomplishment of this maneuver is in large part dependent upon the tact and the skill of the surgeon. Often painful and clumsy unsuccessful efforts have been made to reduce the shoulder. The patient should be told at the outset that the effort to reduce the shoulder by the Kocher maneuver may occupy ten or fifteen minutes and that extreme patience and effort will be necessary on his part to bring about as much relaxation of the muscles of the shoulder as possible. He will be best treated while lying on his back (Eliason; Ashhurst), although occasionally having him seated on a stool or bench will be more feasible. The surgeon should be comfortably seated at the affected side. The maneuver may best be described by breaking it up into the following components: (*a*) The forearm is grasped at the wrist and elbow, with extreme gentleness so

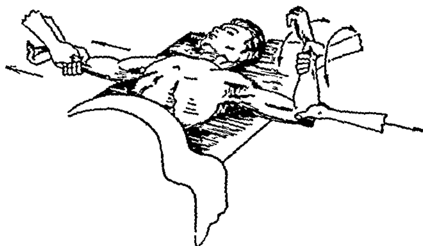


Fig. 292.—Dislocated shoulder. Illustrating the position of the patient and the direction of the forces for reduction of a dislocation. (Bush, L. F.: Am. J. Surg. 67: 520, 1945.)

as not to produce any inadvertent motions of the arm. The forearm is flexed to a right angle upon the arm, and with great patience the elbow is slowly brought inward until it touches the thorax. The elbow should be so guided in this maneuver that it comes to rest an inch, or 1½ inches, posterior to the midaxillary line (Fig. 289). Some three or four minutes may have been consumed in carrying out this first step. (*b*) The forearm, which up to this time has been directed anteriorly, is now slowly and gently swung around to the side so that it points as far laterally as possible (Fig. 290). This step causes external rotation of the head of the humerus. (*c*) The elbow and forearm are now brought forward and upward anteriorly so that the arm gradually assumes the position at right angle to the body and directed anteriorly (Fig. 291). By this time the luxation may have been reduced. (*d*) The forearm in the fourth step is now swung rapidly inward and across the front of the body (Fig. 291). It must be emphasized again that the degree of success in the Kocher movement will be directly dependent upon the patience and gentleness of the operator. Should the maneuver fail, a second trial may be made or another method used.

be made upon the wrist. It will generally be best to pull straight laterally, placing the foot against the chest wall close to the axilla. In one case the writer was compelled to exert this traction in the case of a nervous woman for about ten minutes before reduction was effected. Bush[180] says the following method has been "entirely successful in all anterior, posterior and inferior or subglenoid dislocations." After *x*-ray examination ½ grain of morphine is given, either by the subcutaneous or intravenous route. With the patient lying supine, an assistant applies firm traction on the opposite arm, or the same force may be obtained by placing a sheet around the thorax. Gentle, constant and increasing traction is applied on the involved arm, with the elbow flexed at a right angle, the forearm being held in a vertical position. The patient is reassured and asked to breathe deeply and relax the shoulder muscles. While constant traction is maintained, the flexed arm is gently rotated toward the head, as shown in figure 292. The head of the humerus then slides into the joint with ease. (See Fig. 292.) The method of Milch[181] is shown in figure 293. With care it may usually be done without an anesthetic. The method of Zierold[182] is shown in figure 294.

Walker[183] has contributed the following original method, which he has used for forty years:

"In a right shoulder dislocation the procedure is this: Place the patient on his back at full length on a table. Bring his right side to the edge of the table letting him grasp the [illegible]

and grasp his right wrist with your right hand.

"Place your left hand on the dislocated shoulder joint for the purpose of manipulating the head of the humerus. Apply traction by rotating your body, bringing his right hand nearer to his right side, your body acting as a large fulcrum.

"Reverse the procedure for left shoulder dislocations.

"Main advantages are: Little, if any, danger of injury to the bone, and the gradual and easy application of traction."

Dislocations which do not yield to these measures, or in which the patient will not cooperate because of pain, will require general anesthesia for reduction.

[illegible]

violent closed methods and give a quicker and more complete return to function in the bargain. If open reduction in these cases is not feasible, because of lack of material or personnel or any other contraindicating factor, I feel that traction-suspension with the concurrent use of heat and light massage is preferable to the foot in the axilla and similar violent and gross methods, and just as effective, if not more so, with the added advantage of not inflicting further pathologic changes."

In all cases of dislocation of the shoulder it will be well to make an *x*-ray examination following reduction to see if there has been any minor fracture of the humerus or scapula. Of course, in all cases in which there is any suspicion of a fracture of the surgical neck of the humerus, or the diagnosis of dislocation of the humerus is not perfectly evident, an *x*-ray examination should be made *before* any treatment is attempted. In considering the complications of dislocation of the shoulder, Rixford[178] says: "Muscle rupture is so common as to be almost a necessary part of the process of dislocation, especially of the subscapularis, the supraspinatus is not rarely



Fig. 295.—Posterior dislocation of the elbow with fracture of the coronoid process and the appearance after reduction.

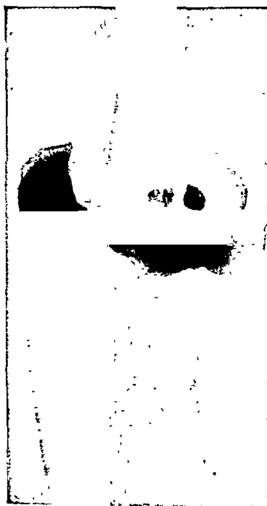


Fig. 296.—Dislocation of the elbow; anteroposterior view.

torn off its insertion, the biceps tendon may be dislodged from its groove and become an obstacle to reduction, but it is seldom divided.

"Nerve injuries, sometimes with more than temporary paralysis, are not rare, also damage to the axillary vessels. I have seen gangrene of the hand from obliteration of the axillary artery in a forward dislocation of the shoulder."[184]

The arm will be suspended in a sling for ten days to two weeks, after which gentle active motion and massage are started. The arm sling manufactured by Zimmer* (Fig. 297) is useful. Eliason [185] fastens the arm to the chest by a Velpeau bandage or sling and circular band for a week, taking care first to place powdered gauze in the axilla. At the end of a week the dressing is temporarily removed for slight motion and care of the skin. Abduction should be avoided for at least four weeks. This may be accomplished by a

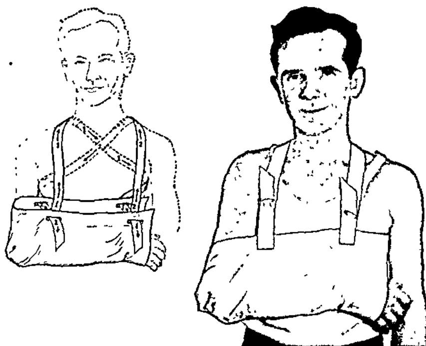


Fig 297.—Zimmer arm sling which prevents pull on the neck.

strap[186] which limits the distance which the elbow may be moved from the side. If sufficient care is taken, the rent in the capsule will heal, and there will be an excellent result. Following reduction of a dislocation of the shoulder joint, Speed[187] gives his patients the following typewritten instructions:

"1. Not to raise the arm above a right angle to the thorax for at least two months after the dislocation.

"2. All motions with the injured arm in dressing and bathing which involve reaching must be avoided for a similar period.

"3. In crowds keep the hand of the recently reduced dislocation in the coat pocket.

"4. Do not run to jump on a street car or any moving conveyance where the arm might be jerked."

In cases of recurrent dislocation of the shoulder, surgical treatment is

* Zimmer Manufacturing Co., Warsaw, Ind.

indicated. The most generally satisfactory operation is that described by Nicola.[188] Magnuson and Stack[189] have had about 20 per cent recurrence with the Nicola operation and have devised an operation in which the insertion of the subscapular muscle is transplanted. They consider their results with this operation to be superior.

Dislocation of the Elbow.—Falls upon the extended hand or twists of the forearm may bring about dislocation of the elbow. Dislocation of the elbow may be backward, forward or lateral (Figs. 295, 296). One or both bones of the forearm may be involved. By far the commonest is the backward dislocation. The existence of this injury may readily be recognized by inability to flex the arm, by the marked prominence of the olecranon process and by the unnatural depression of the arm immediately above the olecranon process. Rarely it will be possible to reduce this dislocation without anesthesia or with local anesthesia (Fig. 298). Much more commonly general anesthesia



Fig. 298.—The employment of local anesthesia in a dislocation of the elbow. (Rice, C. O.: Surg., Gynec. & Obst. 52: 887, 1931.)

will have to be employed. Backward pressure is made upon the lower end of the humerus and, by alternately flexing and extending the forearm and at the same time placing traction upon it, the olecranon fossa may generally without much difficulty be hooked over the lower end of the humerus. The arm may be grasped from behind with the thumbs on the tip of the olecranon and the forearm gradually forced forward, or it may be bent across the knee so as to produce traction of the forearm with countertraction on the arm.

In all cases of suspected dislocation of the elbow an x-ray examination must be made before any manipulations are carried out, because of the frequent occurrence of transverse fractures of the lower end of the humerus with backward displacement of the lower fragment. When the swelling has become marked and even in the absence of swelling, this injury may closely simulate posterior dislocation of the elbow. The reduction of a fracture of this type would require different manipulations than reduction of a dislocation. When the roentgenogram confirms the diagnosis of dislocation of the elbow,

it is quite common to discover a coincident fracture of the tip of the coronoid process of the ulna. This fragment generally resumes its approximate previous position after the manipulation and rarely gives rise to trouble. Cotton[190] has seen 10 cases of dislocation at the elbow in children from 9 to 14 years which were accompanied by a tearing off of the isolated epiphysis of the internal epicondyle, which, in turn, was dislocated into the joint in the process of reduction. These dislocations were accompanied by an ulnar nerve lesion, which is never complete. The treatment is the operative removal of the offending epicondylar epiphysis.[191] After the dislocation has been reduced, the arm will be put up in a moderate degree of flexion and held there either by sling or by a transverse adhesive band from the wrist to the upper arm. This band must have beneath it adequate padding to prevent cutting into the skin of its edges. Gentle active motions should be instituted on the fourth or



Fig. 299.—Calcified deposit about the head of the radius in a case of probable spontaneous reduction of an elbow dislocation.

fifth day, and massage or heat treatment will be carried out from that time on. Eliason advises maintaining the acutely flexed position for a week and does not remove all restraint until the end of four weeks. It would seem, however, that an earlier removal of restraint would accelerate the recovery. By the fifteenth or twentieth day, all but 45 degrees of extension should be obtained. In adults, however, complete extension rarely occurs before the third or fifth month, and the patient should be apprised of the likelihood of this considerable period of time before recovery takes place. An uncommon complication of dislocation of the elbow is the formation of an exostosis from the head of the radius which curves upward along the biceps tendon and, by impinging on the humerus, limits flexion. Operative excision of this exostosis and possibly the head of the radius may be necessary. The author has seen a calcified deposit about the head of the radius following what probably was a spontaneous reduction of an elbow dislocation (Fig. 299).

Dislocation at the Inferior Radio-Ulnar Articulation.—This injury may be caused by extreme torsion of the wrist. Reduction in this rare injury is accomplished by extension and immobilization for a relatively long period—four weeks. Passive motion may be begun at the end of twenty days.[192] Regan

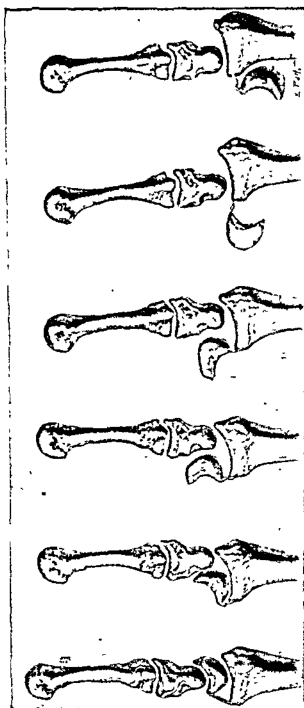


Fig. 300.—The lunate bone in normal position and in varying degrees of rotation. (MacAusland, W. R.: Surg., Gynec. & Obst. 79: 256, 1944.)

and Bickel[193] have devised a fascial sling operation for instability of the lower radio-ulnar joint.

Dislocations of the wrist are extremely uncommon, and the deformity in the posterior type will resemble a Colles fracture. Forward dislocation of the wrist is rare. Several other varieties are described. The dislocation will be

the flexor muscles, and to have it held there by an assistant; then bend the thumb strongly back, extend, pull the thumb toward the fingers and suddenly flex (Fig. 302). If these maneuvers fail, open operation will be required. The immobilization should be maintained for three weeks. Forward dislocation is readily reduced by strong extension and flexion.

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into the joint socket." Balogh[209] reports an isolated dislocation of the first metacarpal. Nutter[210] points out that "interposition of sesamoids in metacarpophalangeal dislocations frequently adds to the difficulty of reduction of these dislocations" and that "when the

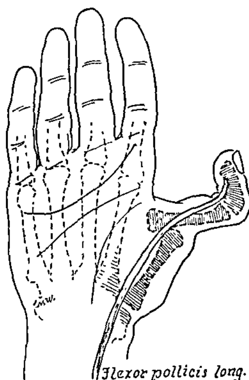


Fig. 301.—Diagrammatic representation of dislocation of the thumb. The proximal phalanx may be engaged behind the flexor pollicis longus tendon.

Dislocation of the Phalanges.—These dislocations are easy of diagnosis and usually are readily reduced by extension and manipulation. They should be fastened in flexion over a roller bandage, or splinted for one week at least. A number of dislocations of the phalanges are irreducible without open operation.[211]

Fractures of the Upper Extremity.—*General Remarks.*—Some of the older rules which were laid down as guides to the diagnosis of fractures are now obsolete. The elicitation of crepitus generally is barbaric and unnecessary. The history, appearance, general configuration of the limb, and site of tenderness as appreciated by gentle palpation generally will suffice to make

a diagnosis. Any patient who has suffered from a fall or a blow, who experiences pain in any part of the upper extremity and who has reluctance to move the extremity must be considered as having a potential fracture. Inspection of the extremity will very commonly show a deformity pathognomonic of fracture, and further diagnostic procedure will be unnecessary. In the absence of deformity the surgeon will palpate the affected extremity with extreme gentleness, beginning with that portion which probably is *insensitive* to pain and gradually approaching the probably tender area. If there is tenderness to slight pressure over any part of the bone, fracture should be suspected. The first concern of the surgeon will be in regard to the best means of comfortably transporting the patient to a place where an x-ray examination can be made. In the majority of cases of any fracture of the upper extremity it will be most expedient simply to permit the patient to rest his forearm upon

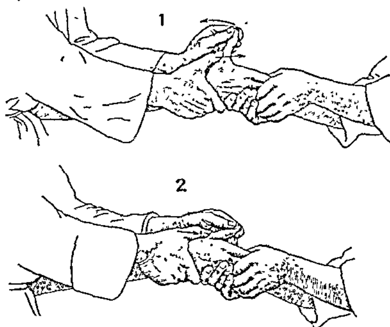


Fig. 302.—Reduction of a dislocation of the thumb. 1, Extension of the thumb with downward pressure at the base. 2, Continued pressure at the base of the thumb with flexion and traction. (Maisonnet, J.: Petit chirurgie, Paris, Gaston Doin et Cie, 1928.)

a pillow or support it in a sling. Often the patient will prefer to support the injured extremity by grasping the forearm and carrying it. In cases in which there is marked abnormal mobility of the forearm or in the wrist so that the slightest motion is painful, a temporary splint will be applied. This will be made of wood, cardboard or whatever suitable material is at hand. It will be padded with cotton and gently bandaged to the forearm, care being taken to apply the bandages loosely over the fracture site and firmly above and below it. Many patients with complete fracture of the humerus are best transported without any fixation. In others the humerus will be bandaged firmly to the side with a Velpeau bandage. Once the patient has been brought to the x-ray laboratory, roentgenograms will be made in two views. Reduction will be accomplished and immobilization carried out. A standard rule in the treatment of all fractures of the extremity is the avoidance of too tight a bandage. The application of a circular plaster cast in a fresh fracture

immediately after reduction and before the maximum swelling has been obtained, is the classic cause of ischemic contraction.[212] Moore[213] says: "A well-supervised delayed reduction is better than a poorly supervised immediate reduction." Speaking on the basis of over 7000 fractures treated at Temple University Hospital, Moore makes a plea for a planned time of reduction on the fourth to the eleventh day. All fractures of the long bones are immediately immobilized in plaster-of-paris splints, and the patient returns at the proper time for formal reduction. This treatment was followed in 4936 cases of simple fracture. It is not advised in cases of compound fracture, nerve or vessel injury or simple dislocation.

Compound Fractures.—The basic principles of the treatment of compound fractures are: (1) treatment of shock and hemorrhage, (2) prevention of wound infection, (3) treatment of wound infection if it develops and (4) accurate reduction and complete immobilization.[214] The treatment of shock and hemorrhage is considered elsewhere. Prevention of infection is most frequently attained by skilful effort to convert the compound or open fracture into a simple or closed fracture. The skin and wound are painstakingly cleansed with soap and water, as described in the section on open wounds. All devitalized or contaminated tissues, *skin or underlying soft parts except major nerves* and vessels are cut away. (See the section on débridement.) The fracture is reduced by manipulation or traction and immobilization maintained preferably by external fixation with casts or traction or if necessary by internal fixation. The wound is closed without tension. Although closure of the wound without the use of sulfonamides has been successful, [215] *implantation of sulfonamides* in the wound has received strong endorsement. Some surgeons endorse the oral or parenteral administration of sulfonamides.

Jensen and Nelson[216] report on 212 compound fractures which were treated by means [illegible] Minneapolis General Hospital from approximately 27 per cent to 3.3 per cent Local implantation of sulfanilamide in compound fractures reduced the average hospital stay per case from 96.3 to 30 days. Two cases of gas gangrene occurred, less than 1 per cent, in 212 consecutive compound fractures treated with local sulfanilamide, while 7.3 per cent of the control series treated without sulfanilamide developed gas gangrene." At the Henry Ford Hospital the infection rate in compound fractures has been reduced from between 15 and 20 per cent to 9.7 per cent by the local implantation of sulfanilamide. Good results with sulfonamides have also been reported by Frankel and Funsten,[217] Campbell and Smith,[218] Venable and Stuck, Kennedy,[214] Griswold[220] and Key and Burford.[221] It is also endorsed by Compere[222] and Thomson.[223]

The Orr-Trueta treatment of compound fractures has been largely adopted by English military surgeons, who believe that it gives superior results both in mortality and morbidity rates. In the opinion of Wilson[224] this method of treatment is a great advance in cases of compound fracture resulting from projectiles. Orr[225] says: "It is constantly and consistently overlooked that the important point in the treatment of the compound fracture consists, not [illegible]

must be not a technic, a method or a chemical cure, but a program." The essential points in the Orr-Trueta treatment[225] are: (1) reduction of the fracture, (2) cleansing of the wound, (3) removal of dead or dying tissue, (4) wound cavity left wide open and filled with vaselin-gauze packing, (5) gauze dressing and well fitting plaster-of-paris cast, (6) cast and dressing changed infrequently (every four to six weeks). The Spanish surgeon Trueta[226] emphasizes five points: (1) prompt surgical treatment, (2) cleansing of the wound (soap and water for the wound and iodine for the surrounding skin), (3) thorough excision of the wound (including a narrow strip of skin and a radical amount of fascia and muscle without incision of the periosteum), (4) provision of drainage (fine-mesh dry gauze in the wound with occasional rubber tubing counter-drainage) and (5) immobilization in a plaster-of-paris cast (applied directly over the skin except for padding of bony prominences). Trueta thinks sulfonamides should be used in wounds as a preparation for skin grafting or when operation must be delayed more than eight hours.[227]

Sherman[228] favors irrigation of compound fractures with a concentrated solution of sodium hypochlorite (4.05 per cent) and sodium chloride (3.25 per cent) by means of Carrel tubes. Pulaski and Chandlee[229] endorse zinc peroxide, and Davidson[230] recommends azochloramide. Sulfonamides in carbowax (see the previous section for the formula) should be of value.[231] Weinberg[232] has obtained excellent results in the treatment of established infection in 28 compound fracture wounds by topical application of a mixture of penicillin and lubricating jelly (1000 units per cubic centimeter).

Epiphysial Separations.—Fractures of the lower radial epiphysis may cause a serious deformity. Falls or blows upon the upper extremity in young children *may cause an injury of the attachment of the epiphysis to the diaphysis.* Union of the epiphysis with the diaphysis or shaft occurs at different ages in different bones, but, according to Stimson,[233] the union "is usually complete in all in the female at the age of twenty-two years, and in the male at twenty-five years." Bergenfeldt[234] classifies epiphysial injuries and associated bony damage as follows:

"(*A*) Pure epiphyseal separation, in which the fracture line involves only the conjugal cartilage—38 per cent of his cases.

"(*B*) Mixed epiphyseal separation, in which the epiphyseal separation is accompanied by fracture of the diaphysis or epiphysis or both—62 per cent of his cases, divided as follows:

"(*a*) Separation with partial fracture of the diaphysis at one end of the epiphyseal line—50 per cent. (*b*) Separation with fracture of epiphysis—6 per cent. (*c*) Separation with fracture of the epiphysis and diaphysis—4 per cent. (*d*) Separation with juxta-epiphyseal fractures—2 per cent."

Scudder says that greater force is required to cause separation of the epiphysis than is required to cause a fracture of the same bone. This may be merely a wrench of the attachment without any pathologic change visible in the *x*-ray plate. The diagnosis in this case will be made by the history of the injury, the situation of the tender area and the negative *x*-ray evidence. In many cases, however, particularly at the lower end of the humerus and radius, the epiphysis will be completely torn loose from its attachment and displaced. According to Cotton,[235] *separation of the entire lower humeral epiphysis is possible up to 4 years of age. The location of the displaced epiphysis will be made certain by x-ray,* and it will be reduced much in the manner of the displacement of fragments of bone (Figs. 303–306). In very

young children, where the epiphysis is largely cartilaginous, the x-ray examination will give little information. General anesthesia most commonly will



Fig. 303.—Epiphysial separation of the head of the humerus.



Fig. 304.—Correction of the epiphysial separation shown in the preceding figure. The deformity recurred each time the arm was brought to the side. A successful result was accomplished by having the child lie in bed with slight traction on the widely abducted arm and with the forearm suspended.

be required. x-Ray examination will invariably be made after reduction to insure the attainment of a proper position. The period and degree of immobil-

ization will be less than that in the case of fracture. Early mobilization will accelerate recovery. Heat and gentle massage will be of value.

Eliason and Ferguson[236] reviewed 110 epiphysial separations and concluded, in part, as follows: "1. Perfect reposition of the displaced epiphysis does not necessarily insure subsequent normal growth. (In this series there were only 3 cases of premature ossification of the

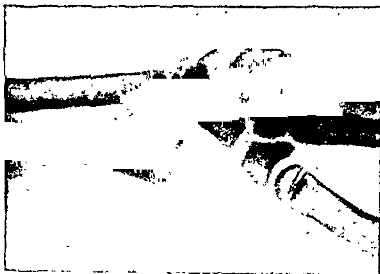


Fig. 305.—Epiphysial separation of the radius.

epiphyseal cartilage. In all 3 instances perfect anatomical reduction was accomplished soon after the injury.)

"2. In most instances in our series in which a single epiphysis ...

age groups nature seems able to compensate for considerable displacement.

"3. Perfect reposition is most desirable in those areas where several ossification centers are involved in the formation of the entire epiphysis, *e. g.*, lower humeral epiphysis. Dis-



Fig. 306.—Reduction of the epiphysial separation shown in the preceding figure. Incorporation in molded plaster splints.

placement of these epiphyses and subsequent abnormal overgrowth may give marked impair—

"4

ray

Trea

"5. The prognosis of epiphyseal injuries should be guarded because of the danger of premature ossification and because the extent of the injury cannot always be determined at the time of injury."

Kaplan[237] says that epiphysial injury often results in some disturbance of bone growth as seen in later x-ray films (18 of 19 cases—Compere[238]) but much less commonly is there arrest of growth sufficient to cause any visible deformity (5 per cent of cases—Bergenfeldt[234]). Bisgard and Martenson[239] found that fractures in the long bones of children "involve the epiphysial cartilage in more than 10 per cent of cases. Deformities of clinical importance developed as a result of disturbances of growth in only six cases, or 2.5 per cent, of the fractures in children less than 16 years of age. These six cases represent only 12 per cent of fractures in which the epiphysial cartilages were involved in the injury despite [illegible]

growth appear months after a fracture has healed and continue to progress during the remainder of the period of growth, every child with a fracture which involves the epiphysial cartilage should be observed periodically for a year or more and his family warned of the possibility of this sequel."



Fig. 307.—Impacted fracture of the head of the humerus. The patient did not go to a physician for a week, after which she was treated with a sling and physiotherapy.

According to Watson,[240] "fracture of the lower radial epiphysis is the most common of all the epiphyseal fractures." The prognosis in these cases must be guarded, as there may be arrest of growth or temporary deformity. Ireland,[241] in speaking of epiphysial separations, says, "Open operation is to be avoided if the fragments can be approximated otherwise. Judging from the results obtained in this series, open operation should be done only when absolutely necessary, as it seems to cause a poor result."

(See the sections on Volkmann's Contracture and on Physical Therapy.)

Fractures of the Humerus.—*Impacted Fractures of the Head of the Humerus.—Impacted Fractures of Anatomic Neck.*—Falls upon the outstretched hand, falls upon the elbow and direct violence upon the shoulder itself may cause impacted fracture of the head of the humerus. Here the shaft is driven for a very short distance into the head; only one side of the bone generally is involved (Fig. 307). No immobilization is required in most cases other than the employment of a sling. In cases of marked pain the upper extremity may be temporarily (from five to seven days) immobilized by a Velpeau

bandage. Early mobilization with heat and massage to the shoulder will bring about recovery in from three to five weeks.

Fractures of the Greater Tuberosity of the Humerus.—This injury may be the cause of considerable disability. It is accompanied by pain on external rotation and tenderness at the site of the fracture. The proper treatment is the immobilization of the shoulder joint in external rotation. Operation is occasionally necessary. Isolated fracture of the *lesser tuberosity of the humerus* is rare. A case is reported by Stangl[242] with a fairly good result following open operation.

Incomplete Fractures of the Shaft of the Humerus.—If only 50 per cent of the shaft of the bone has been involved in a fracture of the humerus, the immobilization provided by a sling for three or four weeks, coupled with early mobilization of the joints, is all that will be required for cure in these cases. If more than 50 per cent of the shaft of the bone has been fractured,



Fig. 308.—Fracture of the surgical neck of the humerus, erroneously considered a dislocation of the shoulder by a practitioner, who attempted to reduce it.



Fig. 309.—Fracture of the surgical neck of the humerus, shown in the preceding figure, after reduction under full anesthesia.

the likelihood of inadvertent fracture of the bone, converting the injury into a complete fracture, calls for firm immobilization with a Velpeau bandage and axillary pad for from three to four weeks. Violent exercise in these cases should be absolutely prohibited for a period of eight weeks at the very least.

Fractures of the Surgical Neck of the Humerus.—The deformity in fractures of the surgical neck of the humerus is often such as to lead the inexperienced to make a diagnosis of dislocation and to make an ill advised attempt to reduce it. It generally should be possible to make the diagnosis by inspection and palpation, but *x*-ray examination is indispensable (Figs. 308–309).[243] The treatment is reduction under full anesthesia. If the fracture is above the insertion of the pectoralis major, the shaft will be pulled mesially (Fig. 308). If the fracture is below the pectoralis major, the proximal fragment will be pulled mesially.[244] Occasionally the aid of the fluoroscope will be required. Stevenson, Leddy and Desjardins,[245] in a discussion of *dangers of roentgenoscopic study*, conclude:

"1. Too much emphasis cannot be laid on the danger, to the physician and to his patients, of reducing fractures under roentgenoscopic guidance.

"2. The careless roentgenoscopist may, while reducing a single fracture, subject his hand or fingers to severe injury which may not become apparent until weeks or months later. He may thus expose himself to a dose of roentgen rays which, though less than an erythema dose, may later by its cumulative effect result in injury to the skin. At the same time, the patient also may receive an excessive dose which may be masked by pain caused by the fracture and which may not be detected because of inflammation associated with the fracture, especially when the limb is in a cast."

The arm usually is immobilized in a Velpeau dressing, but the aeroplane splint is sometimes indicated in older individuals.[246] (Figs. 308–309) Henderson[247] has described an abduction splint with a traction post which is used at the Mayo Clinic. Magnuson[248] believes that in practically every injury about the shoulder joint which requires immobilization the arm should be held in more or less complete abduction and in some cases partial flexion, with external rotation included in most cases. Howard and Eloesser[249] believe that the much used abduction treatment of fractures of the surgical neck of the humerus is wrong, theoretically and clinically. The displacement of the distal fragment is produced by the abductor muscles of the shoulder, the latissimus dorsi, the teres major and the pectoralis major. Abduction of the arm increases the pull of these muscles. These authors conclude that if the long head of the biceps is intact, fractures of the surgical neck of the humerus may be reduced most readily by traction on the arm in a neutral position (not abducted), with simultaneous manual manipulation of the distal fragment. If the long head of the biceps is ruptured open, operation should be resorted to if satisfactory reduction is to be accomplished. After reduction, the most stable position of the fracture is with the arm bandaged to the body over a small axillary pad.

Eliason and Johnson[250] say: "1. In a series of 100 fractures of the upper end of the humerus seen by us, 89 required and submitted to some type of fixation or operation. *Simple fixation at the side was used in 63 cases or 70 per cent; the arm was dressed in* abduction in 19 cases or 21 per cent; operation was performed in 5 and traction in bed was used twice. 2. Of 56 patients that were followed, 89.4 per cent had a satisfactory result."

These authors conclude: "1. Simple fixation at the side is shown to be a valuable form of treatment in fractures of the upper end of the humerus. 2. It is especially valuable in [illegible]

Brostrom[252] emphasizes the value of early mobilization in fractures of the upper end of the humerus. Santi[253] found that of 465 fractures of the humerus, 38 involved the upper end, 64 the diaphysis and 363 the lower extremity. That remarkable recovery may occur in uncorrected fracture of the surgical neck of the humerus is evidenced by the case reported by Sullivan[254] (Fig. 310).

Complete Fracture of the Shaft of the Humerus.—Because of the difficulties attendant upon reduction, because of the frequency of nonunion, because of the likelihood of musculospiral nerve involvement and because of the difficulty of proper immobilization, complete fracture of the shaft of the humerus often presents serious therapeutic problems.

[illegible] of treatment are well stated by Rogers[255] He studied 82 fractures [illegible] concluded: [illegible] results of fractures of [illegible]

"2. In general, transverse fractures should be reduced by manipulation (closed or open) *and held by fixation (external or internal)*; oblique fractures should be reduced and held by constant traction and comminuted fractures should be treated by the simplest method suited to the individual case.

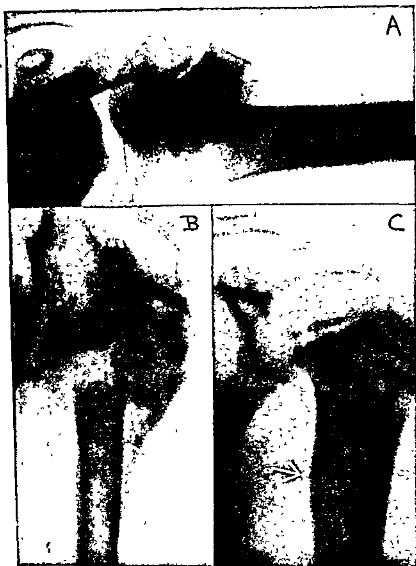


Fig. 310.—*A*, An uncorrected position following a fracture of the proximal end of the humerus. *B*, One month later, showing beginning realignment of the shaft. *C*, Four months after fracture, showing almost complete anatomic restoration. (Sullivan, J. E.: Ann. Surg. 107: 594, 1938.)

"3. Constant traction is dangerous in transverse or short oblique fractures, especially where they occur in the middle and lower thirds, and should be used only with great caution, if at all, under these circumstances."

A transverse fracture of the shaft of the humerus may often be reduced with the patient under general anesthesia and immobilized with a Velpeau bandage with a very satisfactory result. If there is a spiral oblique fracture,

overhead traction by means of a Kirschner wire through the ulna is a satisfactory form of treatment. Open operation is occasionally necessary.

In 1933 Caldwell[256] introduced the "*hanging cast*" method of treating fractures of the humerus. He[257] describes the method as follows:

"A plaster cast is applied from the axilla to the hand over stockinette only. The elbow is flexed to 90 degrees; the forearm is in mid-pronation. A wire loop is incorporated in the cast just above the base of the thumb, and through this a piece of bandage is threaded which passes about the patient's neck. We instituted the use of this loop when we found that patients would move the sling up the forearm toward the elbow in order to relieve the pull on the shoulder. When the fracture is high, near the insertion of the deltoid, the upper fragment is often abducted and causes angulation at the break. In such cases we place a wad of sheet cotton over the inner aspect of the elbow and cover this with plaster. This acts as does a Mitteldorph triangle, abducts the lower fragment, and alines it with the upper fragment.

"When the fracture is very oblique, spiral, or comminuted so that reduction cannot be accomplished, or when the fracture is compound, or the patient badly shocked, our common practice is to put the patient to bed and apply balanced traction with the arm abducted 45 degrees and the forearm flexed to 90 degrees. When reaction has subsided and the patient's vigor has returned, the hanging cast is applied.

"Patients are cautioned not to rest their elbows on chair arms or other objects and to sleep with their shoulders well elevated. After 7 to 10 days the patient is instructed to rotate the humerus within limits of comfort, and in 2 weeks he is directed to abduct his arm as far as he can comfortably. Usually in four weeks the cast can be removed and a sling substituted, and movements of rotation, swinging and abduction can be amplified." Sometimes the cast is left on for six weeks and is always followed by the use of a sling. Union is usually complete in eight weeks. After three months, the patient can as a rule raise his arm to the vertical position. The patient may sleep in a semi-reclining position without support of the cast at the elbow, or traction on the cast may be effected by means of a rope over a pulley at the foot of the bed. The hanging cast method was used in 103 cases with good results by Winfield and his associates.[258] This method has been adopted "almost exclusively" by Stuck and Hinchey.[259]

Fissure Fractures of the Lower End of the Humerus.—Transverse and linear vertical fissure fractures of the lower end of the humerus without displacement of the fragments are properly treated by immobilization in a sling with early mobilization and heat.

Supracondylar fractures of the humerus commonly occur after a fall upon the hand, particularly in children. The shaft may be broken above or through the condyles. One or both condyles may be partly or completely fractured. There may be a vertical fissure extending upward from the joint. Siris[260] made an analysis of 330 supracondylar fractures for which treatment was given on the Children's Surgical Service of Bellevue Hospital during the past eighteen years:

[illegible] vard [illegible] the [illegible] just [illegible] eous [illegible] eive such a longitudinal thrust.

In elbow fractures, the distal fragment of the humerus almost always goes upward and backward, but also may go laterally in either direction, depending upon whether the impact is received on the thenar or the hypothenar side of the hand.

The diagnosis generally is obvious from the deformity, pain, loss of use, history, swelling and ecchymosis, but an *x*-ray examination should never be omitted. Reduction should be prompt and should be attempted only with the patient under full anesthesia. When there is not a great amount of swelling the accuracy of the reduction may be determined with considerable certainty by palpation, but it is best to attempt the reduction in a room where the assistance of the *x*-ray may be obtained if desired. Brewster and Karp[262]



Fig. 311.—Hanging cast. (Caldwell, J. A.: Surg, Gynec. & Obst 70: 421, 1940)

say that "the functional end-results in the treatment of supracondylar fractures are uniformly good, even when the fractures are not necessarily accuately reduced."

Potts[263] has given some valuable instructions in regard to reduction of supracondylar fracture of the humerus. This author says: "Two movements are essential—traction and hyperflexion. The assistant holds the humerus while the surgeon grasps the wrist with one hand and the lower fragment with the other, placing his fingers around the condyles and his thumb against the lower end of the upper fragment. With steady, firm traction on [illegible] [illegible]b upon the upper fragment, [illegible] fragment will not come into [illegible] [illegible]g apposed the surfaces, the [illegible] is hyperflexed and accurately superimposed upon the humerus. Hyperflexion is defined by Ashhurst as that degree of flexion which can be obtained without cutting off

the radial pulse. Because a valgus deformity at the elbow is less deforming than a varus, some prefer to overcorrect by bringing the little finger in line with the great tuberosity of the humerus. The forearm is then dressed in the flexed position and rotated medially across the chest. If the forearm is brought across the chest before hyperflexion is complete the lower fragment will tend to rotate upon the upper, to separate laterally and override medially. Healing in this position will result in a valgus or gunstock deformity."

"To retain the reduction of the fragments so as to prevent a cubitus deformity, the part must be immobilized with the elbow flexed and the forearm semi-pronated."[260]

In all cases an x-ray examination will be made after reduction (Figs. 312–316). The hyperflexion position is defined by Sir Robert Jones as about 5 degrees less than full normal flexion. The author lately has put the arm up almost at a right angle so there is less likelihood of any circulatory



Fig. 312.—Fracture of the lower end of the humerus.



Fig. 313.—Fracture of the lower end of the humerus, shown in the preceding figure, after reduction. Note that the elbow is held in the Jones position of hyperflexion, in which the triceps tendon acts as a very efficient splint.

disturbance. The position of hyperflexion may be maintained with several strips of adhesive tape placed across between the forearm and the arm. This adhesive tape is well padded so as not to cut into the skin. A posterior molded plaster-of-paris splint is very comfortable in the early days of the injury.

Wilson[264] says: "Reduction may be performed as follows: With the patient anesthetized [illegible]

[illegible] elbow slowly flexed. If the reduction is performed within a few hours of the injury before there is any vascular interference from swelling, and if the replacement is complete, it [illegible]

Miller and his associates[265] obtain traction on the ulna by means of a No. 10 eyelet screw which is screwed into a hole made under local anesthesia with a 3/16 in. drill. Countertraction is obtained by means of the padded sidebars of the child's crib (Fib. 314). Hart[266] treats supracondylar fractures by means of traction on a Kirschner wire drilled transversely through the proximal end of the shaft of the ulna.

Occasionally the swelling of the elbow becomes so great that obstruction to the circulation occurs, and the forearm must be lowered. The attendants should be cautioned to observe most carefully the temperature, pulse and sensation in the affected hand. (See the section on Volkmann's Contracture.) When walking the flexed arm may be carried in a sling, but when sitting or lying it is best elevated on a pillow to diminish the tendency to swelling.



Fig. 314.—Traction suspension with a screw in the ulna for severe supracondylar fracture of the elbow. (Miller, E. M., et al.: Ann. Surg. 113: 1098, 1941.)

Murray[267] reported a case of supracondylar fracture put up in the Jones position. "Some hours later there followed great pain and distress and marked swelling of the whole elbow, forearm, and hand. The hand [illegible]

[illegible]

understanc [illegible]
immobiliz [illegible]
of swelling [illegible]
Murray ul [illegible]
the olecrar [illegible]

Nelson[268] reports a case in which there were the classic signs of impending ischemic contracture, namely, a supracondylar fracture occurring in a child, aged 9, a brawny

induration in the arm which was gradually increasing, persistent severe pain, cyanosis of the hand and limited voluntary flexion of the fingers. After exactly eleven hours a 4 inch longitudinal incision was made on the medial side of the front of the elbow joint. The skin was so tight that it appeared to split apart in front of the knife. The incision was continued through the deep fascia, which was as tightly stretched as the skin. A quantity of dark red fluid welled up from the incision, and after this fluid had been wiped away, a small spurting artery, probably the anterior ulnar recurrent, was found in the depth of the wound and ligated. The fracture was inspected, and the position of the fragments seemed to be satisfactory. An examination of the median nerve and brachial artery was now possible. Distal to the elbow the artery was difficult to identify, owing to its great constriction, but on being traced upward both median nerve and brachial artery were seen to be nipped between the surfaces of the fracture. The fragments were gently levered apart and the artery and nerve released. The artery was intact, and the pulse returned at the wrist; the nerve was flattened but did not appear to be torn. The margins of the incision could not be drawn together, and a gap of 1 inch remained. The induration in the arm disappeared wtihin three days, and in ten days the limb had returned to its normal size. At no time did the fingers or wrist show any contracture. There were



Fig. 315.—Severe fracture of the lower end of the humerus.



Fig 316.—Fracture of the lower end of the humerus, shown in the preceding figure, after reduction.

All the muscles of the arm .ingers were normal, and the on the volar surface of the easing d uses city of assive e first varus value

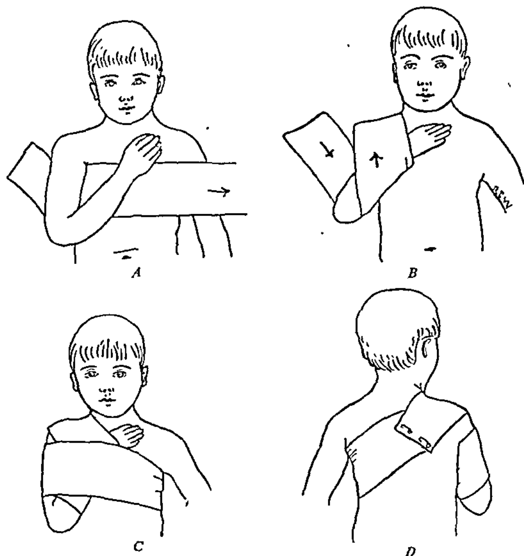
of occupational therapy in the treatment of joint fractures.[271] Jones[272] made a study of nerve lesions in elbow injuries and came to the following conclusions:

"1. Primary ulnar palsy in elbow injuries has the same pathogenesis as delayed ulnar palsy, in that it is produced by traction in cubitus valgus deformity.

"(*a*) It is relatively frequent in *outward* dislocation but not in backward and outward dislocations. It is most common in outward dislocation with displacement of the internal epicondylar epiphysis into the joint, because in addition to having been stretched, the nerve is now kinked or twisted at the joint level.

"(*b*) Injuries of the internal epicondyle are only associated with primary ulnar palsy when they have been produced indirectly by traction. Contusion injury is rare.

"(*c*) In supracondylar fractures, forward and outward displacement of the distal fragment is necessary for primary ulnar palsy to arise by traction over the fractured margin.



[illegible] and skin surfaces with talcum powder. (Allison, N.: J. A. M. A. 89: 1568, 1927.)

"2. Primary musculospiral and median palsies in elbow injuries are due to traction in backward displacements. They are not serious in backward dislocations, but frequently require exploration in supracondylar fractures.

"3. Primary ulnar palsy in wrist injuries rarely arises by traction, because the nerve has free mobility, but *sometimes* complicates *severe displacements of the lower radial* epiphysis when the injury is due to contusion by the radial diaphysis."

Allison[273] believes that the Lund swathe is the best method for general use of securing hyperflexion. The swathe is described as follows:[274] "A cotton swathe of the width of the

shoulder, and long enough to make a figure-of-8 around the elbow and body, is passed under the flexed elbow horizontally, its center being at the point of the elbow. The proximal end is carried snugly up around the forearm and over the shoulder, and the distal brought



Fig 318.—Unreduced supracondylar fracture. (Beckman, F.: Ann. Surg. 90: 1096, 1929.)



Fig. 319.—Two years following injury shown in the preceding figure. The bony block has absorbed, and flexion is not obstructed. (Beckman, F.: Ann. Surg. 90: 1096, 1929.)

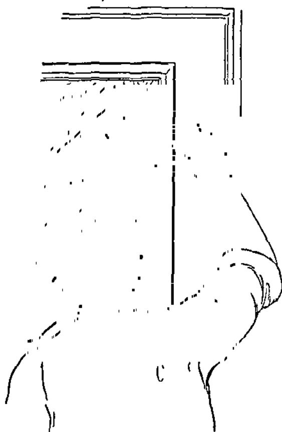


Fig. 320.—Exercise for limbering up a stiff elbow. Dates are placed opposite the marks on the door frame, and children soon become anxious to break their records. (See also Fig. 284.)

forward around the arm, across the front of the chest, and under the opposite arm. It is pinned to the end which has been brought over the shoulder, behind the back of the patient." (Fig. 317)

Beckman[275] reported a very interesting case of supracondylar fracture of the humerus in which it was not possible to obtain reduction. Two years later the end of the upper fragment, which formed the bony block, was absorbed, and flexion, which formerly had been limited to 90 degrees, was now not obstructed (Fig. 319).

Transcondylar (Diacondylar) Fractures of the Humerus.—According to Dunlop,[276] this fracture in children is one "which passes across the broadened distal end of the humerus, and through the very thin portion of the bone known as the olecranon and coronoid fossae. The distal fragment remains

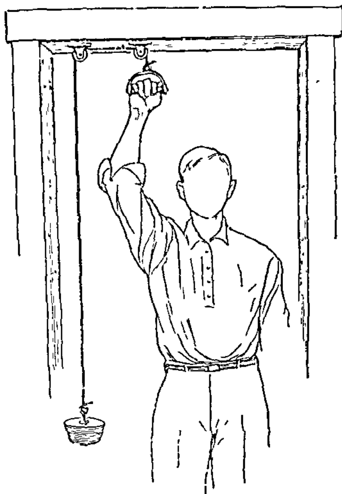


Fig 321.—Simple method of regaining scapulohumeral or elbow motion by patient's own efforts. (Forrester, C. R. G.: Imperative Traumatic Surgery, New York, Paul B. Hoeber, Inc., 1929.)

in one piece. Some authors have spoken of it as an epiphyseal separation, but there is no epiphyseal line at this level of the bone. The epiphyseal line between the capitellum and trochlea and the diaphysis of the humerus is distal to the line of fracture." In the treatment of this condition, Dunlop presents convincing reasons for placing the patient in bed and exerting straight lateral traction by means of adhesive plaster on the forearm. With proper dosage of morphine, Dunlop says reduction should be complete in twenty-four hours. Reduction by manipulation is difficult and often unsuccessful (Figs. 322–324).

all of them).

"Unless there is some definite contraindication, such as shock from other injuries, local infected abrasions or lacerations, or another fracture in the vicinity, the fractures

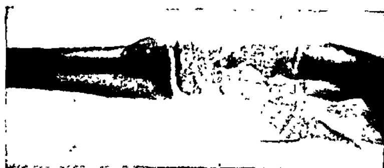


Fig. 329.—Impacted fracture of the lower end of the radius, "sprain fracture." (See Torus Fracture.)

in this group should be operated on immediately, as conservative treatment is merely a waste of time.

"In adults, the head should be removed. . . .

"In children, the displaced head of the radius can be replaced by open operation and a practically normal elbow and forearm may be expected." In a later paper, Key[295] reports survival of the head of the radius in a child after removal and replacement.

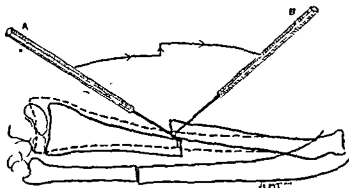


Fig. 330.—Drawing showing a fracture of the radius and ulna at different levels: the fracture of the ulna is reduced; the fragments of the radius are overriding after attempted reduction. *A* represents the position of the lever at the beginning of the reduction. The end of the lever is against the lower fragment, and the shaft of the lever is against the upper fragment. The lever is carried through the arc, as indicated by the arrows, thus overcoming the overriding and depressing and lifting the upper and lower fragments into apposition. The dotted line represents the reduced fracture. *B* shows the position of the lever after it has been carried through the arc necessary to bring about reduction. (Thomson, J. E. M.: J. Bone & Joint Surg. 18: 397, 1936.)

There seems to be a tendency to greater conservatism and fewer operations in the treatment of fractures of the head of the radius. Murray[296] does not remove the head of the radius in children, and in adults he does it only as a last resort when manipulation fails. As in other non-weight-bearing fractures, Ferguson and Erb[297] recommend procaine injection and early mobilization. Meekison,[298] on the basis of 110 cases, concludes that all fractures of the head or neck of the radius require surgical treatment. Jacobs and Kernodle,[299] on the basis of 51 cases, advise treating all fractures of the head of the radius

conservatively except those with marked displacement, in which total excision of the head is required.

Kirby[300] describes a case of fracture of the posterior inner surface of the head of the radius with displacement of the fragment into the joint. He has termed this injury "baseball pitcher's elbow."[301]

Fractures of the Coronoid Process of the Ulna.—Fracture of the coronoid process of the ulna occurs almost exclusively as a complication of dislocation of the elbow. The treatment is immobilization in a sling for two weeks with the early use of heat and massage and guarded active motion.

Fractures of the Olecranon.—Fractures without separation of the fragments or in elderly persons in which the fracture line is proximal to at least part

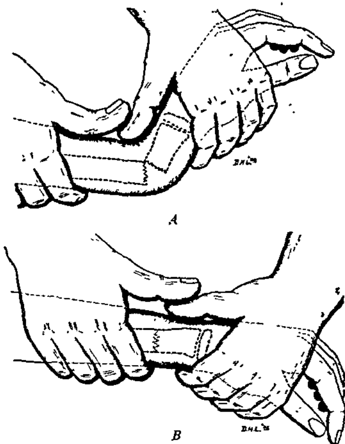


Fig. 331.—*A*, The maneuver, emphasizing angulation and distal push of the superimposed thumbs of the operator. *B*, The alignment of the fragments. (Levinthal, D. H.: Surg., Gynec. & Obst. 57: 790, 1933.)

of the triceps insertion may be treated by fixation in extension or by mere prohibition of flexion. When there is separation of the fragments, open operation with fixation of the fragments is indicated.[302]

Incomplete Fracture of the Shafts of the Radius and Ulna (*Impacted Fracture*).—Gillies[303] describes as *torus fractures* (folding fracture) those injuries which are "characterized by a localized expansion or torus of the cortex accompanied by very little or, in some cases, no displacement of the lower end of the bone." These injuries are sometimes referred to as impacted fractures or infractions.

The diagnosis of torus fracture is made by: "(1) Reluctance on the part of the child to use the extremity following a fall on the outstretched forearm.

(2) A localized swelling located from ¾ to 1½ inches above the wrist. (3) 'Wincing' tenderness on pressure confined to the bone directly beneath the area of swelling. (4) Mild deformity not present in all cases. (5) Absence of crepitus. The diagnosis should always be confirmed by roentgen examination." A posterior molded plaster splint should be worn for ten days to three weeks.

Incomplete fractures of the shaft of the radius and ulna may be of the *fissure* variety or the *greenstick* type. In the former, immobilization with a wood or molded plaster-of-paris splint or even a sling for one to four weeks, depending on the severity, is all the treatment that is required. The splint will be removed twice weekly, at which time the forearm will be soaked in warm water, bathed with alcohol and dusted with talcum powder and the adjacent joints will be manipulated. In the *greenstick* type the bowing deformity will be gently corrected under anesthesia, all possible precautions being taken to prevent the production of a complete fracture. Should a

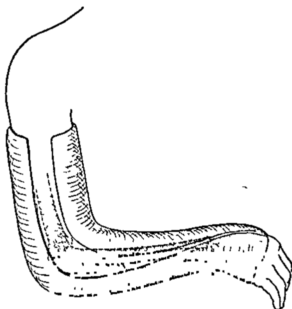


Fig. 332.—Anterior and posterior molded plaster splints, such as are employed in fractures of both bones of the forearm and also for Colles' fractures.

complete fracture with displacement of the fragments occur, it may be necessary to employ the fluoroscope in the reduction. These fractures are best immobilized by means of anterior and posterior molded plaster-of-paris splints (Fig. 332) for a period of four to six weeks, and in the case of young active children a longer time will not be disadvantageous. As in the case of fissure fractures, the splints will be removed two or three times weekly, the arm bathed in hot water, dried and dusted with talcum powder and the adjacent joints given extremely careful active and passive motion.

Fractures of the Shaft of the Radius and Ulna.—Fractures of the shafts of both



Fig. 333.—Complete fracture of both bones of the forearm. Gentle straightening of the arm is all that is required for reduction. Rough manipulation would convert this injury into a complicated fracture with overriding of the fragments. Anterior and lateral views.



Fig 334.—Fracture shown in the preceding figures after reduction and incorporation in molded plaster splints.

a sterile pin between the fragments under *x*-ray guidance (Fig. 330). Thomson used this method successfully in 46 cases in which, in a series of 377 fractures of the forearm, "reduction could not be obtained by ordinary methods, and in which rather extensive open operative procedures would usually be indicated." Open operation is often necessary.

Many surgeons use Lane plates or bone grafts for internal fixation. Bisgard[307] fixes the position of the bones with pins held by the cast. In an analysis of 80 cases of external pin transfixion of fractures, Siris[308] found discharge from the pin sites in 46 per cent, osteomyelitis in 22.5 per cent and death in 10 per cent and believes its routine use should be discontinued. In speaking of complete fractures of both bones of the forearm, Key[309] says: "I believe that if a satisfactory and stable reduction cannot be obtained by a competent surgeon at the *first attempt* in fractures of both bones of the forearm, open reduction and



Fig. 335.—Roentgenogram of typical Monteggia fracture. (Naylor, A.: Brit. J. Surg. 29: 323, 1942.)

internal and external fixation should be resorted to if a competent surgeon and adequate facilities are at hand. For internal fixation, I prefer small stainless steel wire loops. The sprinkling of a small amount of sterile sulfanilamide powder in the wound before it is closed has greatly lessened my fear of infection after open reduction External fixation is, in my experience, best obtained by long posterior and short anterior padded wood splints which are encased in a plaster-of-paris cast. The cast extends from the middle of the arm to the base of the fingers and is so cut out in the palm that free exercise of the thumb and fingers is possible."



Fig. 336.—Fracture of both bones of the forearm (lower third) before and after reduction.

[illegible][310] says: "In children with shaft fractures of both bones of the forearm, complete

Levinthal[313] has given valuable advice as to the manipulative reduction of fractures in the lower third of both bones of the forearm in children (Fig. 331).[314]

Monteggia Fracture.—In this injury there is fracture of the shaft of the ulna combined with dislocation of the head of the radius (Fig. 335). It is easily overlooked. Open reduction is the usual treatment in adults and sometimes in children.[315]

Galeazzi's Fracture.—This is a fracture of the diaphysis of the radius 7 or 8 cm. above the wrist articulation combined with a dislocation of the distal end of the ulna. The treatment is reduction and application of plaster of paris.

Colles' Fracture.—Fractures of the distal end of the radius may be of numerous types, and a great volume of very valuable literature has been



Fig. 337.—Greenstick fracture of the lower end of the radius.

accumulated upon this subject, to which the reader must necessarily be referred for rare or complicated cases. The average fracture of the distal end of the radius (Colles' fracture), however, is of such common occurrence and, moreover, is so generally treated by the first physician to whom the patient is brought that it will seem wise to include it as a minor surgical procedure. Fractures of the distal end of the radius are most frequently incurred by falls upon the outstretched hand. Notwithstanding the fact that nature has

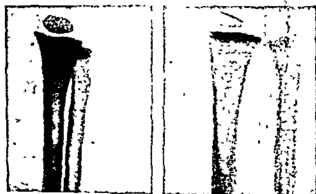


Fig. 338.—Fracture shown in the previous figure, after reduction.

abundantly enlarged this portion of the radius to withstand the many shocks to which it is subject, nevertheless the distal end of the radius is, next to the ribs, the bone most frequently fractured. By a Colles fracture generally is meant a transverse fracture of the distal end of the radius an inch or less proximal to the wrist joint. The distal radial fragment is displaced posteriorly, giving rise to the characteristic "silver fork" deformity of the wrist (Fig. 339 and 340). A very common accompaniment to fracture of the distal end of the radius is fracture of the tip of the styloid process of the ulna. This occurred

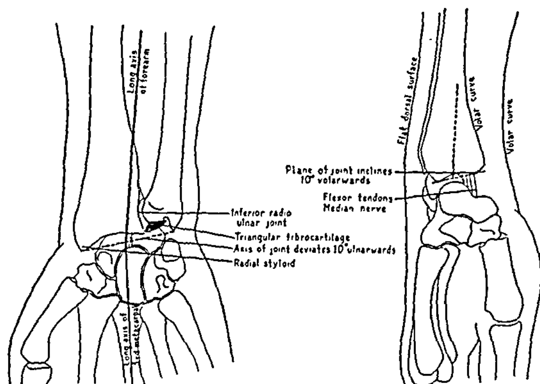


Fig. 339.—Diagram showing the anatomic features of the normal wrist. (McLaughlin, H. L., in Christopher, F.: Textbook of Surgery, ed. 4, Philadelphia, W. B. Saunders Co, 1945.)

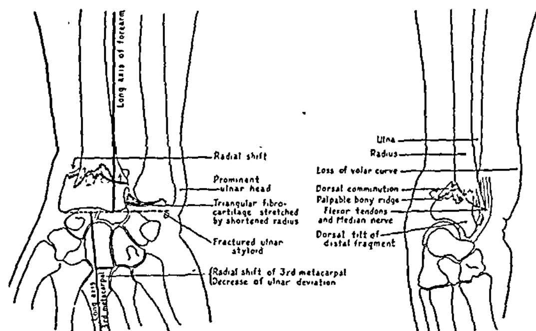


Fig. 340.—Diagram showing the pathologic findings in a fracture of the distal end of the radius (Colles' fracture). (McLaughlin, H. L., in Christopher, F.: Textbook of Surgery, ed. 4, Philadelphia, W. B. Saunders Co, 1945.)

in about 63 per cent of the cases studied at the Mayo Clinic.[316] Ghormley considers fracture of the styloid process important for two reasons: "(1) It no doubt makes accurate reduction more difficult, and (2) tenderness and



Fig. 341.—Colles' fracture with marked displacement of distal fragment.



Fig 342.—Condition of the fracture shown in the preceding figure after reduction.

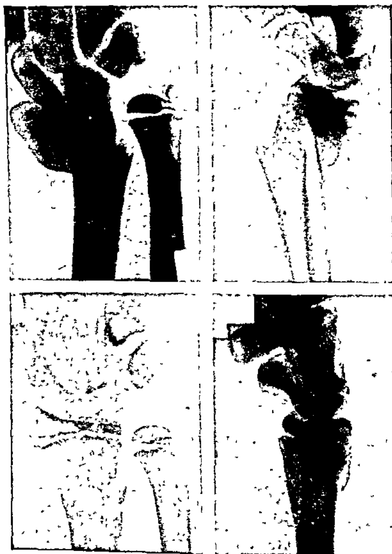


Fig. 343.—Colles' fracture. Above: Before reduction. Below: After reduction.

swelling about the styloid process of the ulna are the most persistent signs of disability." There was a fracture of the styloid process of the ulna in 37 per cent of 424 cases of fracture of the lower end of the radius reported by



Fig. 344.—Fracture of the lower end of the radius.

Edwards and Clayton.[317] There was fracture of the ulnar styloid process in 72 per cent of Cornell's[318] 155 cases, and in 60 per cent of these, nonunion was noted. Carp[319] says: "Most Colles fractures accompanied by fractures of the ulnar styloid have sufficient (96 per cent) displacements of the lower



Fig. 345.—Anteroposterior and lateral views of the fracture shown in the preceding figure after reduction.

radial fragment to warrant reduction in order to obtain the best possible anatomic realignment which is usually essential for the best end-results."

In a *reversed Colles fracture* the distal fragment is displaced in a volar direction. Some of these fractures will require operative reduction.[320] Suc-

cessful closed reductions of reversed Colles fractures are reported by Greeley and Hobart[321] and by Gaynor.[322] Snodgrass[323] points out the liability of confusing fracture-dislocation of the distal end of the radius and true reversed Colles fracture. Fractures extending to the wrist joint—Barton's fractures, reverse Barton's fractures—are different from Colles' fracture, and the treatment is somewhat more difficult.[324]

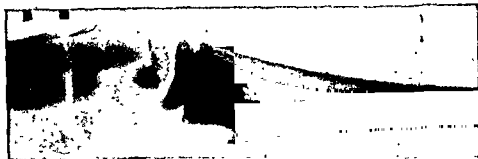


Fig. 346.—"Irreducible" Colles fracture.

In some cases of Colles' fracture there is no displacement of the fragment; in others the fragments are impacted. Fractures with impaction or without displacement of the fragments are recognized by the history of a fall, by the existence of a tender point on the bone and by the x-ray examination (Fig. 329). The treatment is immobilization for ten to fifteen days on a wooden or molded plaster splint, with frequent employment of massage and heat and with active and passive motion during and after this time.

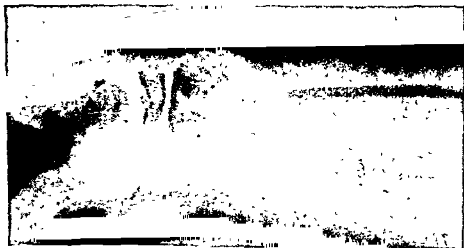


Fig. 347.—Optimum position obtained after repeated attempts to reduce the fracture shown in figure 346. A perfect functional and, to outward appearances, anatomic result was obtained.

In a recent Colles fracture the diagnosis will readily be made by the appearance of the wrist alone. Later, where the swelling has become marked and the silver-forked deformity somewhat obliterated, careful palpation of the bone will elicit the displacement of the fragments. An x-ray examination will decide the question (Figs. 329, 341–343). All Colles fractures should be reduced as soon as possible. An x-ray examination will be made first and the patient then placed under general anesthesia. Local anesthesia may be

employed if general anesthesia is not feasible. (See the section on Local Anesthesia in Fractures.) Unless there is a severe impaction with the displacement, the reduction may be effected by one person alone. Rarely two persons will be required to break up the impaction. The hand of the injured wrist is firmly grasped by the hand of the surgeon in such a manner that his thumb will press on the distal fragment on the dorsal surface. The patient's hand is first tipped backward in extreme dorsiflexion, and then strong pressure and some traction are placed on the distal fragment. In this manner after a few efforts it will generally be possible to move the distal fragment back into its normal position. It is extremely desirable to secure, if possible, exact anatomic reposition of the fragments. After reduction has been effected the surgeon will repeatedly and painstakingly palpate the surface of the injured bone to assure himself as accurately as possible that the reduction is satisfactory. When the distal fragment is somewhat shattered, and exact reposition may be difficult,

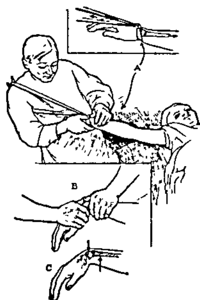


Fig. 348.—Reduction of a Colles fracture. (Magnuson, P. B.: Surg., Gynec. & Obst. 56: 483, 1933.) Usually the bandage loop is unnecessary. Strong thumb pressure on the distal fragment is the most important part of the reduction.

it is important to place it in such a position that the articular surface of the distal end of the radius is inclined slightly downward toward the palmar surface or at least at a right angle to it.

Magnuson[325] describes the reduction of a Colles fracture as follows:

"Traction should be applied over the base of the hand by a bandage loop extending from the hand over the operator's shoulder. First the impaction should be broken up. With the thumbs over the ends of the fragments on the extensor surface of the lower end of the radius, the deformity should be increased until the fracture is perfectly loose and the fragments move freely on each other. Until complete breaking up of the impaction is brought about traction is useless, but when it is accomplished longitudinal traction on the arm will bring the lower fragment down to a point where its fractured surface is at a level with the fractured surface of the upper fragment. Pressure forward with the thumbs on the lower fragment, and backward with the fingers on the lower end of the upper fragment, will then force the fragments into alignment and bring the articular surface into its normal position. (Fig. 348.)

"In elderly patients it is sometimes impossible to re-establish the normal length of the radius, because in the impaction there has been an actual disintegration of cancellous

bone cells, resulting in a loss of bone substance which permanently shortens the radius. In these cases some deformity will remain.

"No one method can be made to apply to all cases, even those of the same type. Variations must be made according to the needs of the case."

The best method of immobilizing a reduced Colles fracture is the employment of anterior and posterior molded plaster of paris splints. These will extend from the metacarpophalangeal junction to a point ½ inch below the elbow. They should be of such length as not to interfere with the action of the elbow joint nor with the flexion of the fingers. The volar splint must not extend beyond the distal flexion crease of the hand. *In all but the oldest patients the author extends the splints above the elbow so as to eliminate supination and pronation* (Fig. 332). The molded splints are made by an assistant, who folds the different layers of rough plaster of paris bandage back

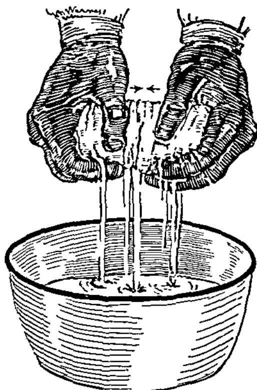


Fig. 349.—Method of expressing excess water from a plaster of paris bandage.

and forth on a flat surface until a plaster gauze mass ¼ inch in thickness and the correct length is obtained. Before making the molded splint, a piece of stockinet is prepared of such size that it is ½ inch larger on each side than the anticipated splint. The splint is then rapidly made by folding the plaster-impregnated bandage back and forth on a smooth surface, care being taken to rub each layer (Figs. 349, 350). The wet splint is then placed on the clean piece of stockinet, and the edges of the latter are turned over on it (Fig. 351). The first molded splint will be then applied to the dorsal surface of the palm and forearm. It is important that it be put in place before it has begun to set. If it has begun to set and is somewhat stiff, it should be discarded and a fresh splint made. The soft plaster of paris splint is smoothly bandaged to the hand, wrist and forearm with one or two thicknesses of thin gauze bandage. No padding of any kind is used. The extremity is then held in a

position of slight eversion (ulnar deviation) of the hand with palmar flexion (Fig. 352) until the plaster has set. Forrester says that "in Colles' fracture the

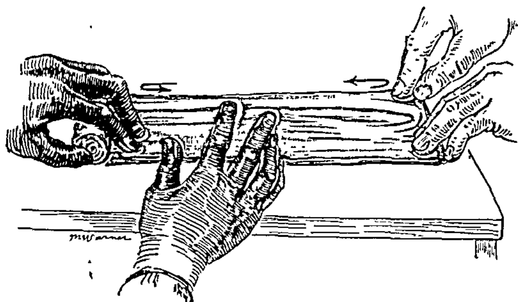


Fig 350.—Method of preparing molded plaster splint. The plaster bandage is turned back and forth upon itself until the desired thickness is obtained. The separate layers are thoroughly rubbed.

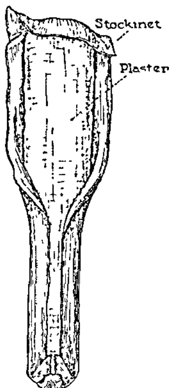


Fig. 351.—Preparation of molded splint.

straight extension position is all that is needed in any type of displacement, providing proper molding with the flat of the hands is used after reduction and while the case is hardening."

Abbott and Saunders[326] warn against the danger of median nerve injury from fixation in acute palmar flexion. Haggart[327] uses a "sugar tong" splint, which passes around the elbow and up both sides of the forearm to the fingers. As Hitzrot[328] says, "You cannot reduce a fracture by a splint."

When the dorsal splint has set, the bandage is removed, and the volar molded splint is applied and bandaged in the same manner (Fig. 352). While the plaster is hardening it is important not to grasp the extremity in such a manner as to cause indentations in the plaster. When the plaster dries, such indentations will cause painful projections into the arm. The splints now receive their final circular bandage, which is best made of gauze. It is applied snugly but not too tightly. The splinted extremity is placed in a sling so adjusted that the wrist is an inch or two higher than the elbow. As soon as the plaster of paris has set, a second *x*-ray examination should invariably be made to insure that the reduction is satisfactory. If it is found to be unsatisfactory, second or even third attempts must be made. The lateral view shows

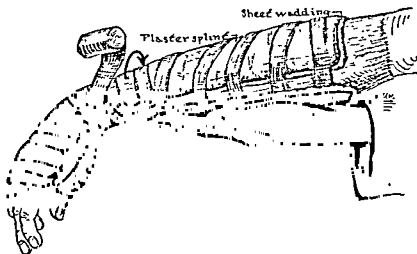


Fig. 352.—The soft molded splints are carefully and smoothly bandaged to the arm. One may be bandaged in place before the other is applied, as is shown in the figure. In most cases it is advisable to extend the splints above the elbow so as to eliminate supination and pronation. The stockinet should be applied to the splints and not to the arm, as shown above.

if the angle of the radiocarpal joint is normal or nearly normal. Sever[329] says: "The normal forward palmar inclination of the radiocarpal joint to the long axis of the radius averages about 15 degrees beyond the right angle; that is, the joint, with the hand pronated, faces distinctly downward to allow for full and free flexion." Sever found in 39 per cent of 199 cases of Colles' fracture that reduction had been improper. The patient is instructed on his return home to put his arm out to the side on a pillow on the table in such a manner that the wrist will be elevated as high as convenient. During sleep the wrist is best placed on a pillow. The patient from time to time will move the fingers and thumb by active motion. He should be warned that he will experience considerable pain and should be provided with aspirin, codeine or other sedative to allay it. It is extremely important that he be given detailed instruction for the recognition of more than ordinary swelling between the splints. The danger that extreme swelling and concomitant tightness of the bandage will cause consequent ischemic contraction is well known. The pain under

such circumstances changes from a steady ache to severe and intolerable discomfort. The fingers, in which slight swelling is permissible, will become markedly swollen. The fingers, moreover, may become cool and will have a sensation of numbness. They may be cyanotic in appearance. Should these symptoms appear and the patient acquaint the surgeon of their appearance, it will behoove the latter to visit him as soon as possible, no matter what time of day or night. The bandages will be slit down the sides, releasing the pressure, and the molded splints will be rebandaged. The patient should be instructed to cut the bandage himself if he cannot reach the surgeon. As the normal swelling subsides from day to day it will be necessary to take up the slack in the bandages by the application of fresh, tighter ones. On the third



Fig 353.—Colles fracture after reduction, incorporated in molded plaster of parie splints. The hand is held in the position of volar flexion. The flexion need not be as extrems as this.

or fifth day, physiotherapy will be started, and this will best be carried out, if possible, by the surgeon himself. The dorsal splint will first be removed and the skin of the extremity exposed. The extremity will be gently stroked for four or five minutes in accordance with the directions of Lucas-Championnière and of Mennell. This stroking will best be accompanied by bathing the skin in alcohol. The skin will be then dried and thoroughly dusted with talcum powder and the dorsal splint replaced. The wrist will then be turned over and, while it is supported in the dorsal splint, the palmar splint will be removed and a similar procedure carried out. As a last step before rebandaging, the wrist will be supported in the palmar splint, and with the dorsal splint removed gentle passive and active motions of the wrist joint carried out. Such physiotherapeutic treatment should be done at least three times a week, preferably

four. After the second week the treatments, which now include soaking in warm water one or twice daily, may be delegated to an intelligent member of the household. At the end of the third week all splints will usually be removed, and the patient encouraged to use his wrist freely in mild exercises which do not require much strength. Speed mobilizes his Colles fractures after the tenth or twelfth day. Ghormley[330] leaves the plaster splints on for a period of seven to ten days, "when they are replaced by an aluminum splint, with the wrist straight or in a slightly cocked-up position. For older patients, in the presence of marked comminution, longer fixation is necessary."

I am in agreement with Haggart,[331] who immobilizes in plaster the elderly patient with a comminuted Colles fracture for *five to seven weeks.* I cannot, however, share his endorsement of the molded sugar tongs splint. Cornell[332] immobilizes the wrist joint three or four weeks but maintains active motion of the fingers from the first.

Amendola[333] says: "About four years ago we began to abandon the use of passive motion and early massage and prolonged the period of fixation. Today I am quite convinced that a better recovery will be obtained in a Colles fracture if one provides, first, uninterrupted fixation of the fragments until union of the bone is secured, and, second, a splint which allows complete function of every muscle and joint that does not have to be immobilized. . . . In children and young adults with simple transverse fractures, fixation for three or four weeks may be sufficient. Very oblique or badly comminuted fractures should be immobilized for four or five weeks, and occasionally for six. When the splints are finally discarded, no supporting bandage is necessary. The patient is instructed to begin active motion at the wrist, and he is seen once a week until he is discharged."

Lewis[334] immobilized his Colles fractures from seven to ten days. Occupational therapy is started a few days later. Weith-Pedersen found that treatment with active motion from the beginning returned the patients to their work sooner than massage and passive motion. On the other hand, three years of experience in treating Colles fractures with plaster of paris fixation for five weeks as advocated by Böhler, convinced Platt[335] that nothing was lost in either the function or the nutrition of the part by the elimination of physical therapy and that the risks of recurrent deformity were minimized. In Cornell's[332] cases there was shortening of the radius, averaging ½ inch in 78 per cent of the cases.

In many cases a leather wrist strap or leather wrist support will be very acceptable to the patient after the splints are removed.

Lippman[336] has made a study of laxity of the radioulnar joint following Colles' fracture.[337] When there is considerable shortening of the radius in a malunited Colles fracture, the distal end of the ulna becomes prominent and may require resection.[338]

Fractures of the Carpus.—Fractures of the carpal bones, while much less common than Colles' fracture, are still not unusual. Soli[339] says that it is difficult to determine the prognosis of fractures of the scaphoid (navicular) as sometimes, especially in boxers, these fractures are not recognized, sometimes they heal with limitation of function from pain or rigidity and sometimes they result in ankylosis. Linear fractures without displacement of any of these bones, the scaphoid most frequently being involved, are best treated, in contradistinction to Colles' fracture, by prolonged immobilization. Bailey[340] points out that percussion of the end of the middle metacarpal reveals the most tenderness in fractures of the scaphoid. After the initial swelling has

subsided a snug-fitting, circular plaster of paris cast is applied and not removed for four to six weeks. When there has been a *complete fracture of a* carpal bone with displacement of a fragment, it generally will be necessary to remove the fragment (or fragments) in entirety.

In discussing fractures of the *carpal navicular* (*scaphoid*) bone (Fig. 356), Speed[341] says that "in very early cases the treatment is immediate immobiliza-

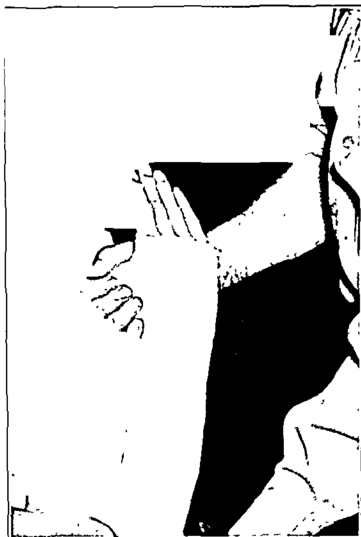


Fig 354.—Type of cast employed in fractures of the carpal scaphoid, showing method of holding the hand while the plaster is drying. Note that the splint is carried to the metacarpophalangeal joints of the fingers and to the level of the middle of the thumb nail. No pressure is put on the tip of the thumb. (Soto-Hall, R.: J. A. M. A. 129: 335, 1945. This article gives the methods of reduction of fractures.)

tion in slight radial and volar flexion for seven to eight weeks, followed by gradual motion and daily baking. With an experience based on 64 cases Sashin[342] believes that fresh fractures of the carpal scaphoid should be immobilized in plaster for three months. In old cases, which have remained undiagnosed for a week or longer, carpalectomy of the navicular bone is the only satisfactory treatment. Cases of long standing with ankylosis may require removal of the entire proximal row." Obletz and Halbstein[343] believe

drilling followed by adequate immobilization is the choice of treatment for nonunited fractures of the carpal navicular bone.

[illegible] scaphoid, Soto Hall[344] says:

[illegible]

This is a rare lesion and usually of isolated occurrence. Full healing should take place in three to four weeks by *simple immobilization of the wrist.*

"In treatment of fractures through the body, the first step should be to determine accurately whether any displacement is present. The lateral film should be carefully studied for angulation. In the presence of displacement, reduction can be obtained by traction on the thumb while the snuffbox is molded by the surgeon's fingers. Once alinement has been attained, the fragments can be impacted and properly immobilized by placing the wrist in full radial flexion with 20 to 30 degrees dorsiflexion and pressing the base of the thumb just below its proximal crease into full abduction. Technically it is preferable to perform this movement by placing the heel of the operator's hand on the same area of the patient's hand. By this method full abduction of the thumb metacarpal is attained while the metacarpophalangeal and interphalangeal joints are allowed to remain in flexion, which is important because this position allows function to return more rapidly when immobilization is discontinued. It is imperative that ulnar flexion should be avoided, because in this position the scaphoid leaves its facet in the articular surface of the radius and moves distally and radialward, the fractured surface tending to separate because the proximal fragment remains attached to the semilunar by the interosseous ligaments. On the other hand, in radial flexion the fragments closely approximate, especially when abduction of the thumb is added to this position. This can be readily demonstrated by producing experimental fractures in cadavers or by roentgenographic studies in the living.

"In the anteroposterior plane, dorsiflexion at 30 to 40 degrees has been experimentally proved by Berlin to be an ideal position. Warning must be given about the use of too much dorsiflexion, because this may lead to anterior angulation of the fracture with eventual malunion.

"*Proper immobilization of the thumb is important for several reasons:*

"1. By its inclusion more complete fixation of the wrist can be attained.

"2. Any active movement of the thumb involves the long flexor tendon and the abductor pollicis. The latter often originates in the tuberosity of the scaphoid, so that abduction of the digit produces motion in the distal fragment. The close relationship of the long flexor to the scaphoid can be shown by noting its anatomic position and by noting movements in experimentally produced fractures, when it can be shown that motion of the interphalangeal joint alters the relation of the fracture surface. Further confirmation can be obtained by asking the patient with recent fracture to flex actively the interphalangeal joint; this movement will produce severe pain.

"3. Correct immobilization of the thumb avoids disability because, in application of the cast, care must be taken to force the thumb into abduction at its base rather than at its tip, since the latter procedure leads either to strain or to subluxation of the metacarpophalangeal joint. In this strained position recovery of function takes place much more slowly. The metacarpal, therefore, should be abducted, and the thumb should be relaxed in slight flexion.

"An anterior skin-tight plaster splint is first applied, and then one layer of circular flannel bandage is wrapped around the extremity. This is followed by a circular plaster splint. It is important that the plaster be carried as close to the elbow as possible and still allow full flexion of this joint, and, as previously mentioned, the plaster should extend to the middle of the thumb nail and to the metacarpophalangeal joint of the fingers. Mobilization of this area in scaphoid fractures will not produce the stiffness one always notes following Colles' fractures.

"Early and rapid healing will take place in fractures of the tubercle of the scaphoid. In this infrequent extra-articular fracture, position of the wrist is not of consequence. On the other hand, fracture through the wrist is the most common, and in this type correct and adequate immobilization is very important. Immobilization should be complete and undisturbed for at least nine to ten weeks; a large percentage of fractures will heal in this time, but four to five weeks longer may be necessary. Roentgenograms and clinical examinations should determine whether this further immobilization is desirable. The presence of local tenderness in the anatomic snuffbox, or pain on percussion on the tip of the thumb,

subsided a snug-fitting, circular plaster of paris cast is applied and not removed for four to six weeks. When there has been a complete fracture of a carpal bone with displacement of a fragment, it generally will be necessary to remove the fragment (or fragments) in entirety.

In discussing fractures of the *carpal navicular* (*scaphoid*) bone (Fig. 356), Speed[341] says that "in very early cases the treatment is immediate immobiliza-



Fig 354.—Type of cast employed in fractures of the carpal scaphoid, showing method of holding the hand while the plaster is drying. Note that the splint is carried to the metacarpophalangeal joints of the fingers and to the level of the middle of the thumb nail. No pressure is put on the tip of the thumb. (Soto-Hall, R.: J. A. M. A. 129: 335, 1945. This article gives the methods of reduction of fractures.)

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drilling followed by adequate immobilization is the choice of treatment for nonunited fractures of the carpal navicular bone.

As to treatment of fractures of the carpal scaphoid, Soto-Hall[344] says:

"Treatment of each type of fracture must be individualized. Fracture of the tubercle offers little difficulty, since the bone in this area is covered by periosteum and is well vascularized. This is a rare lesion and usually of isolated occurrence. Full healing should take place in three to four weeks by *simple immobilization of the wrist.*

"In treatment of fractures through the body, the first step should be to determine accurately whether any displacement is present. The lateral film should be carefully studied for angulation. In the presence of displacement, reduction can be obtained by traction on the thumb while the snuffbox is molded by the surgeon's fingers. Once alinement has been attained, the fragments can be impacted and properly immobilized by placing the wrist in full radial flexion with 20 to 30 degrees dorsiflexion and pressing the base of the thumb just below its proximal crease into full abduction. Technically it is preferable to perform this movement by placing the heel of the operator's hand on the same area of the patient's hand. By this method full abduction of the thumb metacarpal is attained while the metacarpophalangeal and interphalangeal joints are allowed to remain in flexion, which is important because this position allows function to return more rapidly when immobilization is discontinued. It is imperative that ulnar flexion should be avoided, because in this position the scaphoid leaves its facet in the articular surface of the radius and moves distally and radialward, the fractured surface tending to separate because *the proximal fragment remains* attached to the semilunar by the interosseous ligaments. On the other hand, in radial flexion the fragments closely approximate, especially when abduction of the thumb is added to this position. This can be readily demonstrated by [illegible] roentgenographic studies in the living. [illegible] degrees has been experimentally [illegible] be given about the use of too much dorsiflexion, because this may lead to anterior angulation of the fracture with eventual malunion.

"Proper *immobilization of the thumb is important for several reasons:*

"1. By its inclusion more complete fixation of the wrist can be attained.

"2. Any active movement of the thumb involves the long flexor tendon and the abductor pollicis. The latter often originates in the tuberosity of the scaphoid, so that abduction of the digit produces motion in the distal fragment. The close relationship of the long flexor to the scaphoid can be shown by noting its anatomic position and by noting movements in experimentally produced fractures, when it can be shown that motion of the interphalangeal joint alters the relation of the fracture surface. Further confirmation can be obtained by asking the patient with recent fracture to flex actively the interphalangeal joint; this movement will produce severe pain.

"3. Correct immobilization of the thumb avoids disability because, in application of the cast, care must be taken to force the thumb into abduction at its base rather than at its tip, since the latter procedure leads either to strain or to subluxation of the metacarpophalangeal joint. In this strained position recovery of function takes place much more slowly. The metacarpal, therefore, should be abducted, and the thumb should be relaxed in slight flexion.

"An anterior skin-tight plaster splint is first applied, and then one layer of circular flannel bandage is wrapped around the extremity. This is followed by a circular plaster splint. It is important that the plaster be carried as close to the elbow as possible and still allow full flexion of this joint, and, as previously mentioned, the plaster should extend to the middle of the thumb nail and to the metacarpophalangeal joint of the fingers. Mobilization of this area in scaphoid fractures will not produce the stiffness one always notes following Colles' fractures.

"Early and rapid healing will take place in fractures of the *tubercle of the scaphoid.* In this infrequent extra-articular fracture, position of the wrist is not of consequence. On the other hand, fracture through the wrist is the most common, and in this type correct and adequate immobilization is very important. Immobilization should be complete and undisturbed for at least nine to ten weeks; a large percentage of fractures will heal in this time, but four to five weeks longer may be necessary. Roentgenograms and clinical examinations should determine whether this further immobilization is desirable. The presence of local tenderness in the anatomic snuffbox, or pain on percussion on the tip of the thumb,

associated with inconclusive radiologic evidence of union, should warrant further immobilization. Sometimes the clinical evidence of union will appear before it is demonstrated in the *x*-ray."

In late cases with pseudarthrosis or those in which more than three weeks have elapsed before they are seen, the drilling procedure of Schnek[345] is advocated (Fig. 355). Böhler[346] advises fixation in slight dorsiflexion and ulnar flexion and Destot[347] volar and ulnar flexion. Thompson[348] employs a dorsal molded cock-up plaster splint and says that "the period of immobilization should be two to four weeks for fractures of the tuberosities, four to six weeks for the incomplete transverse fracture, and six weeks to three months

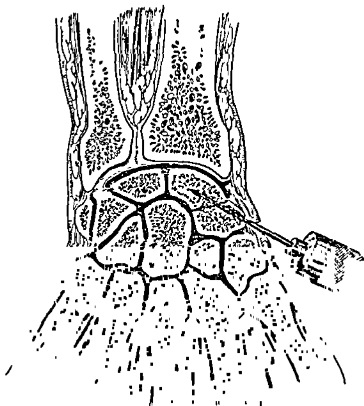


Fig. 355.—Diagram to show the drilling of fragments of the scaphoid bone. Note that the drill enters the scaphoid through its extra-articular, periosteum-covered surface at the approximate point of entry of the artery supplying this bone (Soto-Hall, R., and Haldeman, K. O.: J Bone & Joint Surg 16 822, 1934)

for complete transverse fractures." Jaekle and Clark[349] found failure of bony union in 12.5 per cent of cases. In cases of malunion, Burnett[350] advises grafting rather than incision. This view is shared by Murray.[351]

Johnson[352] says that in fractures of the carpal scaphoid bone the fragments have a sufficient blood supply. There is no periosteal callus. The cartilaginous surface heals by fibrous tissue formation. This worker found no evidence of lytic effect of the joint fluid on bone repair.[353]

The prognosis in fractures of the *os triquetrum* is favorable. Eilers,[354] who has made a study of this subject, says that the treatment is simply rest followed by physiotherapy.

Fractures of the *hamate bone* (Milch[355]), the *pisiform*,[356] the *cuneiform*,[357]

and the *os magnum* and *trapezium*[358] have been reported. Bogart[359] calls attention to the numerous variations in the carpal bones.[360]

Kienböck's Disease of the Semilunar Bone (See section on Osteochondritis). —In this condition there is a traumatic nutritional disturbance with atrophy involving the semilunar bone. Phemister and his associates,[361] from biopsy material in 2 cases of Kienböck's disease, obtained streptococci in culture. Their observations suggest that streptococci play an important rôle in the etiology of Kienböck's, Köhler's and Legg-Perthes' diseases. It is an isolated osteitis or destructive process with fragmentation. A characteristic feature of this ailment is the absence of severe enough trauma to account for the disability. A diagnosis of sprain or rheumatism is frequently made. Speed[362] says: "The pathology probably depends upon interference with the blood supply which arrives at the bone via the ligaments. When a slight trauma is received the ligaments may be torn, the bone nourishment is interrupted, and the absorption begins. Primary fracture often causes the same results because of the impeded vascular supply and the poor osteogenetic properties of the



Fig. 356.—Fracture of the scaphoid bone.

bone. The condition is characterized by local pain and tenderness and wrist-joint disability." According to Goldsmith,[363] "there are four stages to the syndrome, each merging gradually with its successor. The first stage, that of joint irritation immediately following trauma, is comparatively short, generally persisting not more than one or two weeks. There follows a period of relative freedom from discomfort lasting several months. This is followed by the actual disease stage with more severe symptoms. Finally, after several months, the acute symptoms subside into a stage of moderate disability which, as well as the *x*-ray findings, remains unchanged for years." The diagnosis is based on the history and the physical examination but principally on roentgenographic evidence.

Cordes[364] believes that necrosis of the semilunar bone is always caused by [illegible] osis is dependent on the [illegible] possible that trauma is [illegible] more likely that constitutional relations play a part. He reports two brothers with bilateral Kienböck's disease. The pain is aching, annoying and, on excessive use of the wrist, quite severe. There is tenderness

over the semilunar bone with usually slight swelling and a moderate degree of restriction of motion (Henderson[366]). Buchman,[367] who terms Kienböck's disease a "traumatic osteoporosis," calls attention to the fact that the *x*-ray examination is at first negative. The prognosis is unfavorable unless the treatment advocated and so successfully employed by Webb[368] is carried out. This author removed all the fragments of the semilunar bone through a palmar incision of the wrist with the patient under general anesthesia. One of his patients returned to work as a section hand two months after the injury (Fig. 357). Carpal osteitis may also affect the scaphoid and other bones of the carpus.[369] Monat, Wilkie and Harding[370] do not consider Kienböck's disease to be a post-traumatic osteoporosis. These authors recommend excision of the semilunar bone. They say: "The surgical excision should be done through a dorsal incision made over the bone and to the radial side of the extensor tendons to the index finger. The hand should be held in forcible abduction during the operation and all bone particles should be carefully removed."

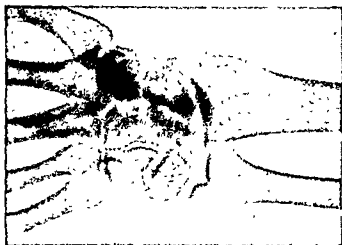


Fig. 357.—Chronic osteitis of the semilunar bone, Kienböck's disease, showing fragmentation of the diseased semilunar bone following slight injury. Treated by excision of the semilunar bone. The patient returned to full duty two months following operation. Recovery complete. (Courtesy of Dr. R. C. Webb.)

Hultén[371] recommends four months' immobilization in cases of mild involvement and extirpation of the lunate bone in cases of severe involvement.[372]

Preiser's disease is the term given to aseptic necrosis of the carpal navicular. A case is reported by Stack.[373]

Fractures of the metacarpals occur following blows upon the knuckles, falls upon the hand or direct violence. The third metacarpal has been broken by a fall on the outstretched middle finger. The third and fourth are most commonly broken.

In a study of 1323 fractures of the metacarpals and phalanges, McNealy and Lichtenstein[374] found the distribution to be as follows:

	Cases	*Per cent.*
Distal phalanx	822	62
Middle phalanx	221	17
Proximal phalanx	189	14
Metacarpals	91	7

A *Bennett fracture* is an oblique fracture of the base of the first metacarpal involving the median volar portion of the articular surface which is associated with slight displacement of the lesser fragment and apparent subluxation of the thumb at the carpometacarpal joint. McNealy and Lichtenstein,[375] in their valuable article, say: "Fractures of the base of the first metacarpal bone are most numerous, occurring in approximately 80 per cent of all fractures of the first metacarpal bone. Only one-fourth of these conform to the description of the Bennett type of fracture. This type of fracture is important because of the functional disability which follows when the fractured bone is allowed to heal without replacement of the fragments in correct apposition." Bressot[376] reports 12 cases of the various types of fractures of the base of the first metacarpal. He says that the oblique extra-articular fractures and the Bennett



Fig. 358.—Bennett fracture of the base of the thumb. (Eliason, E. L.: Am. J. Surg. 6: 501, 1929.)

intra-articular fractures both heal with a 10 to 15 per cent incapacity. With the transverse extra-articular type there is no displacement, and the prognosis is good.[377]

Ehalt[378] has given us the following suggestions in the treatment of fractures of the base of the first metacarpal: Functional treatment is not favored. In recent cases the treatment has consisted of reposition accomplished by abduction and extension without local anesthesia. In cases of subluxation without fracture, Bennett's fracture with and without subluxation, in which only the extra-articular process is broken off, a plaster splint has been applied. In the other types of fracture, with involvement of more than the third of the joint surface, wire extension has been applied. Plaster bandage is applied directly on the skin, and reposition must be maintained until the plaster hardens. The plaster dressing is left in place for four weeks. Wire extension is made on the end phalanx of the thumb. The pull is obtained by means of a Kramer splint, which is fastened to the thumb with a plaster of paris dressing. Only the wrist and thumb joints are immobilized. All of the others are allowed free movement The wrist does not become stiff during immobilization for four weeks. The fracture heals well with this method. In the cases

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Fig. 358.—Bennett fracture of the base of the thumb. (Eliason, E. L.: Am. J. Surg. 6: 501, 1929.)

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reviewed there were no pseudarthroses. Persons with fractures well healed by this treatment do not require compensation as, at most, there is a disability of only 5 or 6 per cent for three months. This is a marked improvement over the usual poorly healed Bennett fracture with severe secondary arthritis for which compensation for disability up to 25 per cent is given for years. Hudson[379] applies skeletal traction to the head of the metacarpal bone with an instrument like a towel clip and then applies plaster to hold the thumb in complete abduction and the wrist in slight dorsiflexion.



Fig. 359.—Spica plaster cast for Bennett fracture. (Eliason, E. L.: Am. J. Surg. 6: 501, 1929.)

Fractures of the shaft of the metacarpals are generally oblique, and the diagnosis is based on the history, pain, inability to use the fingers, point of tenderness, swelling and x-ray evidence.

The anatomy and physiology of the fractures have been emphasized and so lucidly described by Magnuson[380] that one can do no better than to quote from his paper: "In the case of the metacarpals there are attached on each side of each metacarpal the interosseus muscles which originate along the base and shaft on each bone and are attached anterior to the midline on the base of the first phalanx. These muscles are used constantly



Fig 360—Diagram of mechanics of pull exerted by interosseus muscle (*A*). (Magnuson, P B.: J. A M. A 91: 1339, 1928.)

as flexors, and, as a matter of fact, are flexors which do their jobs unusually well for twenty-four hours a day, and in persons who use their hands in more or less hard tasks during a considerable part of each day these muscles attain no mean strength. With the muscles acting as flexors, but at the same time pulling almost in the long axis of the bone,

does two things: it makes the extensor tendons run around two sides of a triangle instead of straight across the back of the bone, and it throws the distal head of the bone into the palm of the hand and shortens the bone, which results in a prominence in the palm of the hand over the ball, which throws an uneven pressure on that point when the patient grasps a hard substance after the fracture is healed (Fig. 360). One might as well carry a marble in the palm of the hand between the handle of a tool and the head of the bone as to have the head of the bone protrude like a marble under the pad in the palm of the hand, which



Fig. 361.—Fracture of the middle metacarpal caused by muscular violence.

is so essential to comfort in lifting or handling hard objects. The flexion produced in the distal fragment produces flexion in the finger, so that the patient is either unable to bring the finger into full extension with the other fingers of the hand, or, if he does, it is necessary for him to hyperextend the metacarpophalangeal joint. He cannot bring the finger into full flexure because the callus on the back of the hand, as a result of the angulation of the metacarpal shaft, shortens the tendon and weakens the grip in this finger. When the inability of the patient to bear weight pressing into the palm of the hand because of the prominence



Fig. 362.—"Punch fracture." Fracture of the distal end of the fifth metacarpal caused by a blow with the fist.

of the distal head of the metacarpal is added to this, it is easy to see that a serious disability may result from an insignificant looking fracture in the shaft of the metacarpal."

The proper methods of splinting fractures of the metacarpals and phalanges may be seen in figure 363. Magnuson believes that the best method of treating this fracture is posterior splinting with a dorsal pad over the point of the fracture and a palmar pad over the distal head. In some cases traction by one of the methods described under finger fractures may be necessary to insure proper position. (See Fig. 36

neck of the metacarpal, Compere and Banks[381] advise the treatment shown in figure 365. Immobilization will be maintained for ten days to two weeks, after which it will be interrupted by periods of physiotherapy.[382]

Fractures of the Phalanges (Fingers).—Forrester and McLean[383] give the following classification of finger fractures: "(1) Chipping and comminuted fractures of the spongy portion of the distal phalanx. (2) Transverse fractures of the shaft. (3) Spiral fractures of the shaft. (4) T-fractures into the joint. (5) Tearing loose of the tendon insertions. Any of these types can be compound rather than simple."

Smith and Rider[384] studied 100 consecutive phalangeal fractures and concluded:

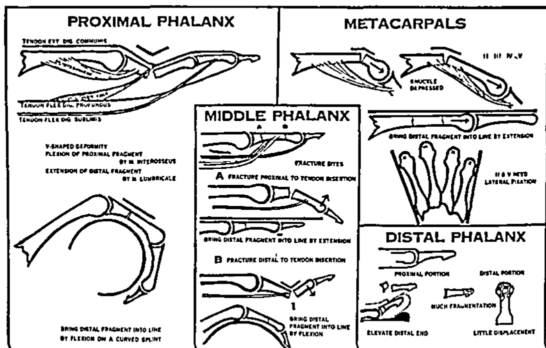
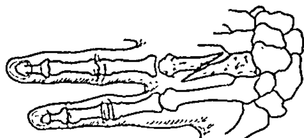


Fig. 363.—Illustrating mechanisms of deformities produced by the action of the intrinsic muscles and tendons with suggestions of means for overcoming these deformities. (McNealy, R. W., and Lichtenstein, M. E.: Surg., Gynec. & Obst. 55: 758, 1932.)

"(1) The average time for bony healing of complete phalangeal fractures of all types, as shown roentgenographically, is approximately five months. (2) Clinical healing requires about one-fourth of the time required for roentgenographic healing. (3) The fracture lines are usually more distinct at the end of thirty days than at the time of the injury. (4) Single or multiple chip fragments in the tips of the distal phalanges practically always reunite and give a normal appearing contour to the distal phalanx. (5) No callus is seen in a chip fragment at the tip of the distal phalanx and there is more callus formation in the proximal phalanges. (6) In none of these cases has there been absorption of any of the loose fragments. (7) It cannot be assumed that there is a lack of bony union until at least one year's time has elapsed."

Simple fractures of the phalanges generally occur following blows upon the tips of the extended fingers from baseballs and the like. Crushing violence, such as being caught by a slammed door or the fall of a heavy object on the

fingers, will cause fractures of the phalanges (Fig. 366). Eliason[385] describes comminuted fractures of the distal phalanx as "bursting" or "tuft" fractures



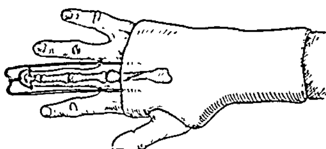
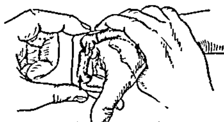


Fig. 364.—Accurate reduction and immobilization of oblique or comminuted fractures of a metacarpal bone require traction. (Compere, E. L., and Banks, S. W.: Pictorial Handbook of Fracture Treatment, Chicago, Year Book Publishers, Inc., 1943.)





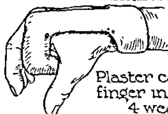


Fig. 365.—This simple fracture is too often badly managed. Malunion leaves the hand crippled because of inability to grasp firmly due to displacement of the head of the metacarpal bone into the palm. (Compere, E. L., and Banks, S. W.: Pictorial Handbook of Fracture Treatment, Chicago, Year Book Publishers, Inc., 1943.)

and points out that when the fragments are separated, it may be necessary to mold them into closer approximation to correct unsightly deformity. It is extremely important to the patient that these fractures of the phalanges be

recognized and very accurately reduced. Pressure on the finger tip is painful. A boy presented himself to a physician some hours after being struck on the tip of the finger with a baseball, because of considerable swelling and tenderness in the region of the distal interphalangeal joint. The physician was able to elicit a certain amount of motion at this joint and, misled by the fact that



Fig. 366.—Comminuted fracture of the distal phalanx.

the swelling obscured the outline of the finger, told the patient that it was all right and to do nothing about it. A month later this patient was referred to the writer because of an ugly bump at this joint. *x*-Ray examination (Fig. 367) showed that there had been a fracture of the distal end of the middle phalanx with displacement of the fragment almost half the width of the shaft. As will be seen in the figure, abundant callus had formed and the likelihood of benefiting the condition by refracture was extremely remote. This fracture, of course, should have been reduced when it occurred. Figure 368 shows a fracture and epiphyseal separation unrecognized by the intern, who took no roentgenogram because the finger "looked straight." Figure 368 *b*, shows the position after reduction when first seen four days after the injury.

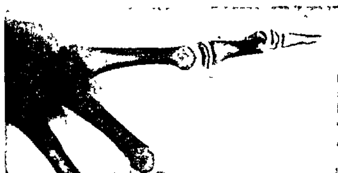


Fig 367.—Unrecognized fracture of the middle phalanx of the index finger. It was given no treatment by the practitioner who first saw the patient. The misplaced distal fragment may be seen to be strongly united by callus. The finger presents an unsightly deformity.

In fracture dislocations of the interphalangeal joints there will be severe permanent disability without adequate treatment. Robertson and his associates[386] have obtained excellent results by multiple Kirschner wire traction with rubber bands to banjo splints. (Figs. 369, 370 and 371.)



Fig. 368.—A, Fracture and epiphyseal separation involving the distal phalanx of the finger; unrecognized by intern because "the finger looked straight." B, Position after reduction.

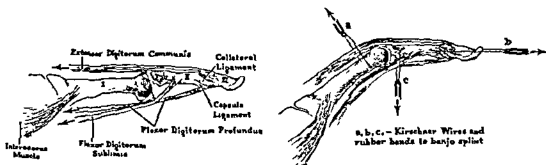


Fig. 369.—A, Typical fracture-dislocation of an interphalangeal joint, showing displacements to be corrected. B, Corrective forces applied by multiple traction. (Robertson, R. C.; Cawley, J. J., Jr, and Faris, A. M.: J. Bone & Joint Surg. 28: 68, 1946.)

Fractures of the phalanges (Figs. 372–373) are often difficult of treatment. Fractures of the base phalanges are particularly difficult because of the opposing action of the interossei and the lumbricales. The interossei flex the proximal fragment.

"The lumbricales, however, which are attached to the fascia and the ligaments of the middle joint, act as extensors when that joint is dorsal to the midline. Whereas, if the

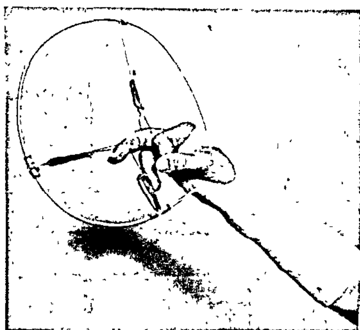


Fig. 370.—Banjo splint and Kirschner wire and elastic band traction in treatment of interphalangeal fracture-dislocation. (Robertson, R C.; Cawley, J. J., Jr, and Faris, A. M.: J. Bone & Joint Surg. 28: 68, 1946.)



Fig. 371.—*X*-ray appearance of Kirschner wire traction in interphalangeal fracture-dislocation. (Robertson, R. C., et al.: J. Bone & Joint Surg 28: 68, 1946.)



Fig. 372.—Lipping fracture of the distal phalanx.



Fig. 373.—Fracture of the shaft of the middle phalanx.

joint is thrown forward they act as flexors of the base phalanx. In fractures of the shaft of the base phalanx, then, the interossei flex the base fragment and the lumbricales extend the distal fragment, which results in an anterior angulation of these fragments, which angulation throws the fractured surface of the bone against the surface of the flexor tendon (Fig 374). If this deformity is not overcome there is union of these fragments, with the distal end and the distal half of the base phalanx in extension and with the proximal fragment of the base phalanx in flexion. The flexor tendons, which run over a knob of callus on the flexor surface of the base phalanx, interfere with the action of the tendon

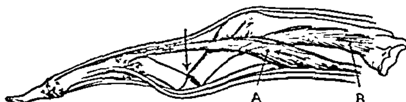


Fig. 374.—Diagram of pull of the lumbricalis muscle (*A*), illustrating extensor action of the distal fragment of the base phalanx with deformity produced with flexor tendon of the finger pushed forward by the fragments at points of fracture; *B*, interosseous muscle. (Magnuson, P. B.: J. A. M. A. 91: 1339, 1928.)

because of adhesions and of pressure. If the finger is flexed, the proximal half of the base phalanx can be brought into flexion, but the distal half of the base phalanx and the two phalanges are in extension so that the finger cannot be brought to the point of contact with the palm, and when the person tries to lift a hard object he finds that the anterior angle at the point of fracture pinches the soft structures, namely, the tendons and skin, subcutaneously, between the angle of the bone and the hard object in the hand, and that he has lost part of his grip because of the inability of the flexor tendons to glide smoothly through their sheaths, plus the inability of the fingers to close, because of hyperextension of its distal part. This weakens the grip and also gives pain."[387] (See also figure 363.)

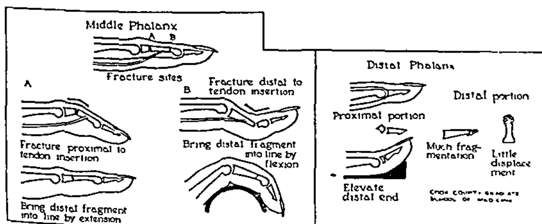


Fig. 375.—The basis for mechanical fixation in the fractures of the bones in the hand. McNealy, R. W., and Lichtenstein, M. E.: Am. J. Surg. 50: 563, 1940.)

In cases of *compound fracture of the phalanges* when there is not sufficient disturbance of the circulation to cause gangrene of the portion of the finger distal to the injury, the wound should be carefully treated according to the methods described in the chapter on wounds. Smith[388] says that compound fractures of the fingers should receive the same painstaking care as similar fractures of the larger bones. He prefers the "closed plaster" method of treatment, which is abstracted as follows:

"Most patients were taken to the operating room. General anesthesia, or nerve block at the wrist or brachial plexus, was ordinarily used, local anesthesia *rarely. The entire* hand, except the wounds, was scrubbed for ten minutes with brush, soap and water. When grease was present the scrubbing was preceded by cleansing with benzene followed by ether. The hand was rinsed with sterile saline solution. The arm was elevated and a tourniquet applied to the upper arm. The hand was prepared with antiseptic, care being taken not to permit any of it to enter the wound. The hand was draped and the surgeon, wearing cap, mask, gown and gloves, continued the mechanical cleansing. The wound was explored and foreign material removed from its depths. The wound was again cleansed with sterile saline solution.

"Careful débridement followed. Blood vessels, nerves and tendons were preserved. When the nail was involved in the injury, it was completely excised. The tourniquet was

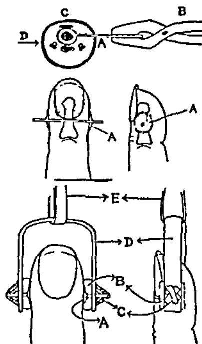


Fig. 376.—At top Insertion of pin *C*, dorsum. The position of the dorsal tendon, ventral tendons and sheath, and digital vessels and nerves indicated. *A*, Kidney needle. *B*, Ordinary pliers (boiled) rotated to and fro to bore needle through phalanx against manual counterpressure at *D*. Skin nicked with knife before penetration by needle. Rigid asepsis is essential.

In middle: *After needle insertion. A*, Thin piece of cotton sealed to skin and to pin by collodion.

At bottom: *A*, Cotton collodion as in previous figure. *B*, Small piece of felt to fill in interval between yoke and dressing to prevent "sliding" of pin. *C*, Adhesive covering sharp ends of pin and acting as hub to prevent shifting of the yoke. *D*, Yoke cut from thin sheet aluminum *E*, Rubber band for elastic traction (Murray, C R.: New York State J. Med. 36· 1749, 1936)

"A small sterile gauze dressing was placed over the wound and the finger bandaged lightly. An unpadded encasement was applied to the finger. With the finger in the desired position, the plaster bandage was made to immobilize the joints above and below the fracture; in case of fracture of the proximal phalanx, plaster was applied to the hand but its application did not include the uninvolved fingers

"The encasements were heavy enough to maintain reduction and protect the finger from

further injury but were not large and awkward. The most satisfactory encasements made from the so-called specialist splints of Johnson & Johnson. Six layers of these s were cut to form two sugar-tong splints which were applied in an anteroposterior radio-ulnar direction. The splints were molded together to form an encasement. danger of a tight plaster bandage such as might be applied by circular turns is thus avc

"The hand was elevated for several hours after operation. A prophylactic dose c gangrene and tetanus antitoxin was administered after the usual skin test. If the p was not sent back to work immediately or the following day, 1 Gm. sulfadiazin administered every four hours.

"The hand was examined daily for three days The encasement was removed afte to two weeks and, if necessary, another plaster bandage was applied at that time."

In fractures of the phalanges, reduction should be attempted and n tained. The position and type of splint best suited to the different phala is shown in figure 375. Position, of course, always should be checke x-ray study. When these methods fail, some type of traction should be i

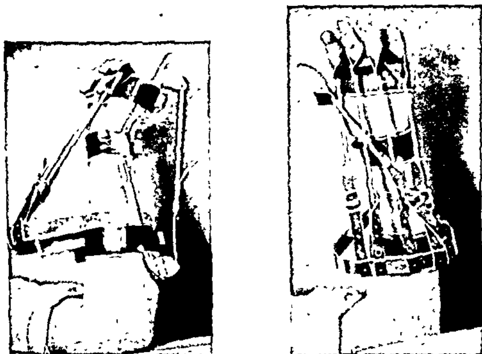


Fig 377.—Corrective splints for stiff fingers and wrist. (Courtesy of Drs. S. L. and M. L. Mason)

tuted. Traction upon the finger may be obtained with adhesive tape, gl small Steinmann pin, fingernail traction or a specially devised finger cal the last two being described by Mock and Ellis.[389] The traction is atta by a rubber band or coil spring under proper tension (Mock uses as muc 8 ounces) to the extension piece of a Walker or "banjo" splint. The spli made fast to the forearm. Murray's[390] method of applying pin traction phalanx is shown in figure 376. Keon-Cohen[391] passes fine wire through phalanx by first passing it through a hypodermic needle which has pushed through the phalanx and then withdrawing the needle. Hart[392] fashioned a simple aluminum splint, the two lower curved arms of which in the crotch on either side of the injured finger. The splint extends se inches beyond the finger, and from its distal end, finger nail, skin or ske traction may be applied.[393] Another traction device for finger fractur

the "safety-pin tongs" of Fowler.[394] By means of pliers and file and 2½ or 3 inch safety pins, very excellent tongs are made. Traction on these was made to a banjo splint which was made from a "¼ inch metal rod incorporated in a plaster shell extending from the wrist to near the elbow." The splint of Knowles[395] is made up as follows:

> "The splint consists of a leather wrist support made of firm leather, with a wire (modified copy of the banjo splint) over it. The wire is attached to the wrist brace by a slide-rod and thumb screw which is easily adjustable. By means of this slide-rod and thumb screw it is possible to make the necessary traction on a finger or fingers and to maintain that traction or to increase or decrease it from visit to visit as one desires without a change of bandage and a great deal of manipulation.
>
> "Should the thumb be among the injured members, a full circular wire (such as the banjo splint) may be used, the ends of the wire going through the slide-rods and being held by the thumb screws."

For fractures of the distal phalanges a dorsal protecting tongue depressor splint is customary and efficient. The bent aluminum splint described by Ellis[396] is useful.

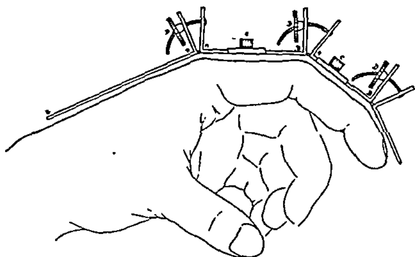


Fig. 378.—Splint for extension or flexion of finger. (Shnayerson, N.: J. A. M. A. 110: 2070, 1938.)

Dr. Sumner L. Koch, of Northwestern University Medical School, has devised a series of extremely ingenious and practical splints for the treatment of stiff joints of the wrist and fingers.[397] Shnayerson[398] has devised an excellent splint for correction of stiff fingers. If only one joint is affected, only one segment of the splint need be used. (Fig. 378.)[399]

Birth Fractures.—The majority of fractures sustained by an infant during birth are amenable to simple treatment. *Birth fractures of the clavicle* are made evident by the reluctance of the infant to move the corresponding arm, by tender swelling over the clavicle and by the *x*-ray examination. This fracture is said to occur in 1 per cent of all births and to be the most frequent fracture occurring during delivery. (Sanford.) The treatment is a posterior figure of 8 bandage or, better, a small-sized DuPuy clavicle brace. Thorndike and Pierce[400] use yarn for the figure of 8 bandage and keep it applied three or four weeks. It is extremely important to keep the skin under the bandage or brace dry or well powdered. *Birth fractures of the humerus* may be treated by applying small coaptation splints and binding the arm to the body by means

of a Velpeau bandage, being first careful to place a small cotton pad and an abundance of talcum powder in the axilla. Such a bandage should be carefully changed at least every third day, and the position should be checked by *x*-ray.

Manipulative Surgical Treatment of the Upper Extremity.—In his very valuable little book, Timbrell Fisher[401] has shown the great importance and value of manipulative surgical treatment *in carefully selected cases.* The cases which are benefited fall into four groups (Fisher):

Joint Adhesions.—These may be intra-articular or periarticular and are associated with acute and chronic synovitis and acute and chronic arthritis In these cases, limitation of motion, pain when an adhesion is stretched, weakness and tenderness generally at the attachment of adhesions are characteristic.



Fig. 379.—Birth fracture of the humerus showing abundant callus formation.

Functional or Hysterical Disorders.—In these cases there may be also organic trouble.

Dislocations or Subluxations.

Adhesion (not related to joints, being in or around muscles, in fasciae and connective-tissue layers as the result of injury).— The manipulations, which should be done in a quiescent period, require an accurate sense of touch and considerable strength. The best results occur, however, in those cases which require little force. "After the restoration of movement to a stiff joint by manipulation, the joint must either immediately or within a few hours be again moved through the increased range, and this movement must be kept up subsequently at regular intervals, to insure success."[402] When movement is decreased by manipulation, the form of treatment or the surgeon's method is at fault. Manipulations are generally best done under nitrous oxide or

ethylene anesthesia. Cases of mild joint adhesion may be cured by radiant heat, massage and active and passive exercises. Detailed instructions, abundantly illustrated by photographs, are given by Fisher for each of the joints of the upper extremity. For more detailed instruction the reader is referred to Fisher's excellent book. (See the section on Manipulation of the Stiff Shoulder.)

Frostbite.—The fingers are the common site of frostbite. (See section on frostbite.)

When amputation becomes necessary the incision will be made ¼ inch above the line of demarcation, and after the proper cutting off of bone, an *effort will be made to arrange the flap so that the suture line is dorsal and the* intact skin on the palmar surface.

Chemical Injuries.—The ill advised application of dressings moistened with phenol and bichloride of mercury and even of aluminum acetate has caused

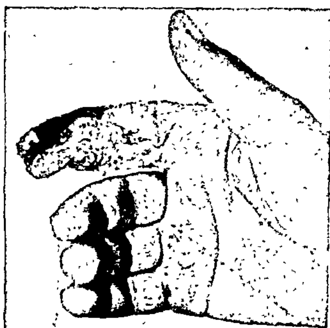


Fig 380.—Gangrene of finger following aluminum acetate dressing. (Hertzler, A. E.: Am J. Surg. 2. 573, 1927.)

necrosis of the superficial skin. These chemicals were formerly much used because of their antiseptic properties, to the occasional great damage of the parts with which they came in contact. Hertzler[403] reported a case of gangrene of the index finger following the use of aluminum acetate (30 grains to 1 pint of water). It became necessary to amputate the finger at the metacarpophalangeal joint (Fig. 380). Phenol and bichloride of mercury *never* should be employed in the treatment of infections. Hot boric or magnesium sulfate fomentations should be used instead. Prolonged spraying of the skin with ethyl chloride for anesthesia has caused necrosis and gangrene, and this anesthetic agent should be employed only with great care. In cases of superficial gangrene resulting from these chemicals spontaneous healing will generally occur following the sloughing off of the gangrenous parts. Amputation occasionally will be necessary.

LOCAL ANESTHESIA IN REDUCTION OF FRACTURES

Of recent years great interest has been taken in the employment of local anesthesia in the reduction of fractures. There are two general methods of employing local anesthesia for this purpose, the infiltration method and method of nerve block. Hosford[404] classifies the methods into five groups, namely, "(1) injecting 10 cc. of a 2 per cent solution of novocaine directly into the hematoma after the method of Böhler; (2) infiltrating the anesthetic around the fracture area; (3) blocking the peripheral nerves; (4) injecting the brachial plexus (for fractures of the upper extremity); or (5) inducing spinal anesthesia." The credit for developing the infiltration method should go to Lorenz Böhler, of Vienna. Böhler[405] describes his method as follows:

"In all recent fractures we used local analgesia, and only in isolated cases regional anesthesia but no longer general anesthesia. We can recommend this form of analgesia since we have used it in more than 3000 cases without the slightest injury, whether in the form of an infection of the hematoma or an intoxication.

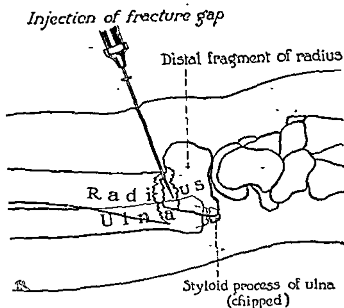


Fig. 381.—Employment of local anesthesia in a Colles fracture. (Rice, C. O.: Surg Gynec. & Obst. 52: 887, 1931.)

"The method of local analgesia is extremely simple in recent fractures. In the usual manner of infiltration anesthesia, such as in operating for an inguinal hernia, we must infiltrate all the tissues. In a recent fracture the circumstances are quite different, since a hematoma is present which penetrates all the tissues in the vicinity of the broken fragments It is sufficient to introduce the needle down to the broken fragments and to inject the solution, which is at once diffused in the hematoma (Fig. 381). The anesthesia takes place immediately and as a result the muscle relaxes. The greatest obstacle to the reduction

(5) tincture of iodine; (6) a few sterile swabs.

"It goes without saying that everything must be sterile; the needles should be applied by means of the tissue forceps and not be touched with the fingers; in order not to be delayed, we should always have two syringes ready. After we determine the site of the fracture, judging by tender point, we paint the skin with tincture of iodine and then introduce the needle until the bone is felt. We now inject 4 to 5 cc. of the solution and take off the

syringe. If a red colored solution escapes from the needle, we know that we are in the hematoma, and now we can inject 15 to 20 cc. of the solution with the same needle. If the solution comes out clear, we must try again until the proper place is found. If the bone is broken in two places or if more than one bone is broken, we inject the solution into the site of every fracture. We can use 50 to 60 cc. of a 2 per cent novocaine solution without any danger. In those fractures, where the displacement is minimal and where the hematoma is small, we are occasionally forced to inject the whole circumference of the bone.

"After the injection we should never lose sight of the patient; because when the pains completely disappear, the patient is liable to make an untoward movement and receive a serious new injury, such as, for instance, to lacerate the [illegible] fragment. I r[illegible] in a sitting p[illegible] to support himself on the broken hand, which was now free from pain. Since this observation, I inject the local anesthetic only when the patient is in a lying position. For the same reason no patient should be made free from pain during transport by the injection of a local anesthetic unless he is accompanied by a physician who understands the possible dangers.

"If we only use ½ per cent novocaine, a few minutes elapse before it takes effect. During this time, if the patient is not watched, he is liable to move and injure himself. We, therefore, limit ourselves to the use of a 2 per cent novocaine solution only.

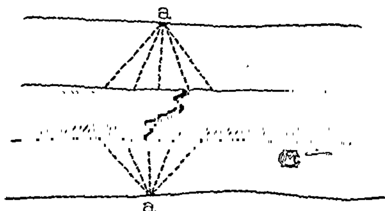


Fig. 382.—Treatment of fractures with local anesthesia: *a*, site of injection. (Lundy, J. S.: Proc. Staff Meet., Mayo Clin. 4: 77, 1929.)

"All the advantages of local anesthesia as compared with those of general cannot be enumerated here. We can only emphasize the following facts. We are able to do away with the severe general disturbances which follow general anesthesia. We can dispense with an anesthetist, which is especially of great importance for the physician who works alone. The patient can go to the *x*-ray room alone, and we can correct the deformity several times if we do not succeed, under the influence of the same anesthesia, which lasts from two to three hours. In particularly difficult cases we can repeat the injection of the anesthetic solution. The relaxation of the muscles is much more pronounced than in cases where a short and rapid general anesthesia is used.

"Individuals with fractured arms can go home unassisted. The danger of injecting the solution into large blood vessels is hardly possible, if one takes the necessary care to avoid them and if one is familiar with the art of local anesthesia.

"Since in fractures with larger hematomas, only a single puncture is necessary, we are often able to use this form of anesthesia for children also. In compound fractures the injection between the fragments should not be done through the soiled wound, but through the neighboring healthy skin.

"In dislocations, the method of local anesthesia offers more difficulty inasmuch as, especially in the shoulder and in the hip, the injection in the joint alone is not sufficient; we must also inject the dislocated parts of the joint which are found lying against the muscles.

"If the fracture is a few days old and hematoma is in the process of organization, it is impossible to inject directly into the hematoma with success; in such cases we inject the

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CHAPTER XIX

INFECTIONS OF THE UPPER EXTREMITY

Erysipelas occasionally occurs upon the upper extremity but is much less frequent in this situation than upon the face or scalp. (See the section on erysipelas.)

Chronic Staphylococcic and Streptococcic Infections of the Skin.—Creeping, serpiginous infections which involve only the outer layers of the epidermis occasionally occur upon the fingers. These infections are characterized by smarting pain and irritation. The finger is slightly swollen, and the superficial layers of the epidermis are lifted up so that thin, watery, nonelevated blisters occur. Hot boric acid fomentations generally are of little avail in the treatment of this condition. It may be very obstinate and disturbing to both the patient and surgeon. The best treatment is to remove the necrotic upper layers of the epidermis by means of very fine forceps and scissors, to remove the purulent secretions beneath and to dress the affected area with a 5 per cent sulfathiazole ointment or a 2 per cent mercurial ointment. Occasionally a patient will be found who is sensitive to sulfathiazole and a severe rash may occur. Most useful is an application of sulfonamides in carbowax (formula given in previous section), which is covered with petrolatum gauze. It may be necessary to use warm boric acid compresses part of the time.

Lymphangitis is a spreading infection involving the lymphatic vessels. It originates from a superficial wound, which may be very small, such as a pin scratch, and spreads proximally through the lymph vessels to the lymph nodes. It is of rather frequent occurrence upon the upper extremity, and when it is neglected, very serious or even fatal results may occur. It is extremely important that the proper diagnosis be made early in this condition, as proper treatment of early lymphangitis is practically always successful and faulty treatment may bring about very bad results. A patient suffering from lymphangitis will generally give a history of having sustained a slight wound of the extremity, or he may not even remember having had a wound. The wound may have partially healed and be covered with scab. The hand or forearm is swollen and painful. It is tender to palpation but *particularly* along the course of the affected lymphatics. The latter may be recognized by their giving rise to the appearance of *red streaks* which run up the arm. These red streaks are tender to palpation and may give a slight sense of resistance to the palpating finger. This is particularly true in the deeper, larger lymphatics.

The general condition of the patient shows prostration, apparently quite out of proportion to the extent of the infection. There will be fever, the temperature reaching 103 or 104 F., elevation of the pulse rate and marked malaise.

The lymphatic channels take the shortest course to the back of the hand and from there are drained through the larger lymph channels to the axilla. In the words of Koch,[1] "The lymphatic vessels from the little finger and ring

finger usually drain into the antecubital and epitrochlear glands, so that these glands may be involved early in infections involving the ulnar side of the hand. The lymphatics of the thumb and index finger usually drain directly into the axillary glands, so that in infections of the radial side of the hand the axillary glands are the first to be involved. Infections of the middle finger may drain into either the antecubital or axillary glands, but in 15 per cent of cases, according to Kanavel, drain directly into the supraclavicular glands, *so that infection arising in the middle finger may early produce severe systemic symptoms.*"

In 1934 Koch[2] published a careful study entitled "Acute Rapidly Spreading Infections Following Trivial Injuries of the Hand." His summary, in part, is as follows:

"Nine patients, among them 2 physicians and 2 nurses, died after intervals of from 4 to 13 days after the original injury. One patient succumbed to a bilateral bronchopneumonia 35 days after the injury.

"Of 20 cases in which bacteriological findings were available a haemolytic streptococcus in pure culture was recovered in 10 cases; a haemolytic streptococcus in symbiosis with other organisms in 3 cases, a non-haemolytic streptococcus in 4 cases, a Streptococcus viridans in 1 case, and a haemolytic staphylococcus in 1 case.

"In 5 cases definite postoperative complications developed subsequent to recovery from the acute infection; and in 4 of these the complications were attributed directly to the antecedent infection.

"Of the 22 patients who recovered all were treated conservatively from the moment they were first seen, with rest in bed, massive warm wet sterile dressings over the entire upper extremity and forced administration of fluids; and in none was the inflammatory process incised until absolute evidence of localization and abscess formation was present."

Elsewhere Koch[3] makes a plea for "education of the public to the fact that in the immediate treatment of injuries simple soap and water cleansing, and protection of the open wound against infection from without, with the aid of a sterile dressing, constitute the best possible form of first-aid treatment and one which is based on sound surgical principles."

The treatment of lymphangitis consists essentially of chemotherapy, rest and warm, moist applications. *Incising is contraindicated.* Incision of an extremity affected by lymphangitis not only does not remedy the condition but is liable to cause its spread locally or bring about systemic involvement. Penicillin (15,000 to 20,000 units; every three hours subcutaneously) or sulfadiazine (1 Gm. with 2 Gm. of sodium bicarbonate every four hours for an adult) or both are given. The affected arm should be elevated upon a pillow and should be wrapped to a thickness of at least ½ to ¾ inch with sterile gauze for an area well beyond the part involved. Koch[4] applies the hot wet dressing from the finger tips to the axilla. This dressing is liberally moistened with a saturated solution of boric acid or normal saline solution, which is preferably applied warm. The wet dressing is then enclosed in a waterproof material, such as oiled silk, rubber sheeting or oilcloth, and outside of this a hot-water bag or electric pad is placed (Figs. 18 and 383). The electric pad may be kept in place by a pinned towel. To keep a moist dressing hot, Koch[4] suspends a powerful light close above it (Fig. 384). Cochran[5] keeps the dressing moist by means of rubber tubes. The moist heat is kept up continuously for twenty-four hours, when the dressing will be changed. At this time the skin will present a wrinkled and dehydrated appearance. The red streaks will be less apparent, and they will be less tender. The skin will be then given a brief respite, say an hour or so, from the hot fomentations, which then will be resumed. This method will be continued until all abnormal appearance

and sensation have disappeared. During this time the patient should be at rest in bed, large quantities of fluids should be administered and free elimination should be secured. Incision should not be carried out unless there is very definite localization with pus formation.

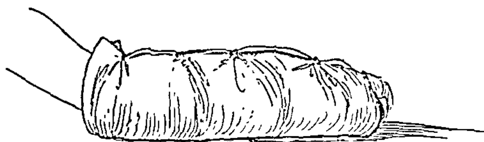


Fig. 383.—Sterile dressing applied to arm and ready to be covered with a light or an electric baker. Every two hours a few pins are removed and the edges of the towel separated for the addition of warm boric acid solution. If a dressing is to be effective in producing hyperemia it must be of adequate size and extend widely beyond the affected area. (After Kanavel, A. B., and Koch, S. L.: Bull. Am. Coll. Surgeons 14: 19, 1930.)

Cellulitis is a diffuse involvement of the tissues by pyogenic bacteria. It differs from lymphangitis in not being limited to the lymphatic vessels. It may be concomitant with a deep abscess, to which it is subordinate in importance pathologically. When cellulitis exists alone, it is characterized by a certain amount of brawny induration of the affected area with swelling and tenderness to palpation. The systemic reaction generally is slight. The treat-

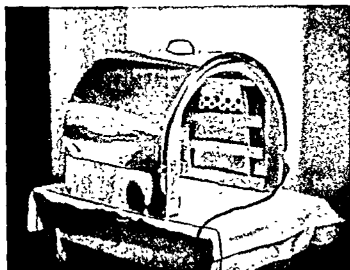


Fig. 384.—Electric baker for maintaining continuous heat over a wet dressing. The control may be turned to "low," "medium," or "high." If kept at "medium" and covered with canvas or with flannel so that no draughts of air dissipate the heat, a constant temperature of 140 degrees can be maintained within the closed space. (Kanavel, A. B., and Koch, S. L.: Bull. Am. Coll. Surgeons 14: 19, 1930.)

ment of this condition consists of the administration of penicillin or sulfonamides (see section on penicillin and sulfonamides) and continuous hot boric acid fomentations. With the employment of this treatment, resolution may occur without abscess formation. More commonly, however, the infection will become localized, and a discrete abscess will form. When the area

of induration has greatly diminished and the abscess seems to have fluctuated and to be well walled off, incision and drainage will accelerate recovery. When there is widespread inflammation which does not respond to hot fomentations, there may be a necrotizing infection of the fascia. This condition will require generous longitudinal incisions.[6]

It is to be remembered that cellulitis in diabetic patients is particularly dangerous. They offer poor resistance to infections, and, moreover, an infection is liable to aggravate mild diabetes to a serious degree.

Furuncle and Localized Abscess.—The diagnosis and treatment of furuncle have been considered elsewhere. Small localized abscesses which do not involve the deeper structures of the hand are not uncommon. To be mentioned in this regard especially is the so-called "*collar button abscess*" (Fig. 385). This abscess generally occurs at the distal edge of the palm, "*web infection,*"

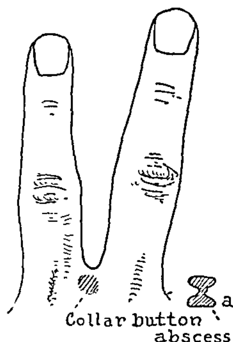


Fig. 385.—Diagram to show collar button abscess at the web of the finger. *a*, Diagrammatic cross section of the abscess

and consists of two compartments connected by a narrow communication. A common error of treatment is to incise the superficial and more accessible pocket and to leave the deeper pocket undrained. The proper incisions are parallel to the long axis of the hand and extend from the web ½ to ¾ inch proximally. It is important to drain both pockets.

Carbuncles involve the forearm and arm more frequently than they do the hand. Their diagnosis, pathology and treatment have been considered elsewhere. (See the section on Boils and Carbuncles.)

Paronychia ("runaround") is a pyogenic infection of the tissues in the neighborhood lateral to the finger nail. These infections most commonly originate from wounds made by tearing or unskillfully cutting hangnails or from trivial abrasions in this locality. The most common site is at the proximal portion of the lateral border of the nail. The pus will accumulate so that a small abscess is formed in this region. If untreated the process may progress

around the base of the nail to the other side, when it is termed a "runaround," or it may burrow beneath the nail and involve the nail matrix epithelium (hyponychium). Auchincloss[7] has made a very careful study of finger tip

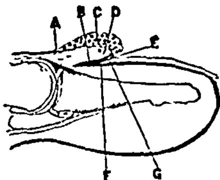


Fig. 386.—Longitudinal section of a finger end to illustrate a "simple" eponychia. *A*, Proximal limits of the "pus blister" in the epidermis of the eponychium. *B*, The "reflected layer" of epithelium from the eponychial epidermis. *C*, Pus in the cavity of the "pus blister." *D*, Inflammatory reaction. *E*, Point where "pus blister" may be opened. Roof of blister to be clipped away. *F*, Nail matrix epithelium. *G*, Nail root. (Auchincloss, H.: Surgery of the Hand, in Nelson Loose-Leaf Surgery, New York, Thomas Nelson & Sons, 1927, vol. 3.)

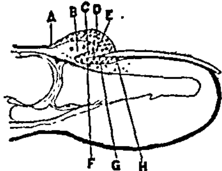


Fig. 387.—Longitudinal section of a finger end illustrating the eponychia associated with a subungual abscess." *A*, Proximal limit of the "pus blister." *B*, Cellulitis. *C*, "Reflected layer" of epithelium from the eponychial epidermis. *D*, Pus in the cavity of the blister. *E*, Nail root separated from matrix epithelium. *F*, Nail matrix epithelium. *G*, Pus beneath the nail. *H*, Cellulitis. (Auchincloss, H.: Surgery of the Hand, in Nelson Loose-Leaf Surgery, New York, Thomas Nelson & Sons, 1927, vol. 3.)

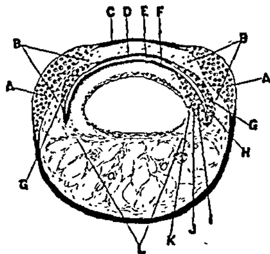


Fig. 388.—Transverse section of a finger end through the matrix, illustrating the pathologic anatomy of a "simple" paraeponychia on one side and a paraeponychia with a subungual abscess on the other. *A*, Pus in the cavity of the "pus blister." *B*, Cellulitis. *C*, Eponychial epidermis. *D*, Reflected layer of epithelium of the eponychial epidermis. *E*, Nail root, *F*, Nail matrix epithelium. *G*, Pus between nail root and eponychial epithelium. *H*, Nail root, separated from epithelial attachments and acting as a foreign body, *I*, Pus in subungual abscess. *J*, Matrix epithelium. *K*, Cellulitis. *L*, Fascial septa separating dorsal from anterior aspect of finger. (Auchincloss, H.: Surgery of the Hand, in Nelson Loose-Leaf Surgery, New York, Thomas Nelson & Sons, 1927.)

infections. He defines *eponychia* as a "pus blister" involving the epidermis of the eponychium (the thin layer of overhanging epithelium at the base of the nail [Fig. 386]). A *subungual abscess* is an abscess under any part of the

nail. A subungual abscess may be continuous with an eponychia or a paronychia (Fig. 387). A subungual abscess may be independent of a paronychia or eponychia. A *paronychia* is an infection or abscess involving the epithelium at the lateral border of the nail. A paronychia may be continuous with a subungual abscess or with an eponychia (Fig. 388). A paraeponychia ("epiparonychia") is a combination of an eponychia and a paronychia (Figs. 389–390). In the early stages of this affection the inflammation will be diffuse

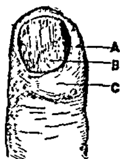


Fig. 389.—Finger end to show the characteristics of a paraeponychia with subungual abscess. *A*, Paronychia. *B*, Subungual abscess. *C*, Eponychia. (Auchincloss, H.: Surgery of the Hand, in Nelson Loose-Leaf Surgery, New York, Thomas Nelson & Sons, 1927.)

without pus formation. Here the treatment consists of continuous hot boric acid fomentations, which will bring about either resolution or a definite localized abscess (Fig. 391). When an abscess has formed a longitudinal incision should be made laterally to the nail margin and the pus evacuated. The incision should be well to the side of the nail, as injuring the matrix may cause the development of an unsightly nail. If the abscess has burrowed

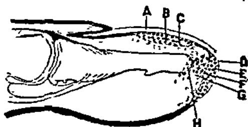


Fig. 390.—Longitudinal section of a finger end to show the pathologic anatomy of two types of dorsal infections not associated with eponychia or paronychia. Subungual abscess: *A*, Nail body. *B*, Pus. *C*, Nail bed epithelium. Finger tip infection: *D*, "Roof" of "pus blister." *E*, Pus. *F*, Floor of "pus blister." *G*, Cellulitis. Here, where the dense corium merges with the periosteum, is the only place in the finger end where a subungual abscess and a bone infection are likely to be associated. (Auchincloss, H.: Surgery of the Hand, in Nelson Loose-Leaf Surgery, New York, Thomas Nelson & Sons, 1927.)

beneath the nail, the latter should be elevated with a small hook, and the proximal portion of it should be cut away with extreme care not to damage the delicate underlying matrix or the overlying eponychium (Fig. 392). Removal of the proximal portion of the nail is advised by Browder.[9] As is aptly said by Auchincloss: "In all these infections, when a subungual abscess has formed, the key to the situation lies in adequate removal of the nail. Failure to do this accounts for the unnecessary prolongation of most of these infections. The whole nail does not usually have to be removed. Such part,

however, as has separated from its subjacent epithelium is like an irritating foreign body in an abscess cavity, and not only should it be removed, but it

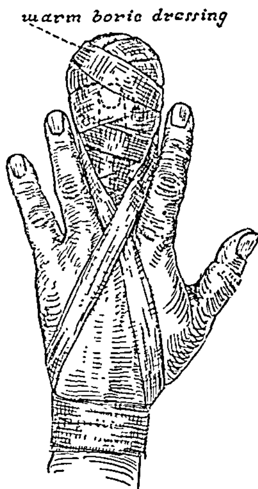


Fig. 391.—Moist boric acid dressing on a finger. Note the large amount of gauze necessary.

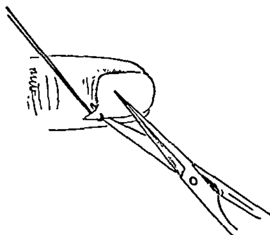


Fig. 392.—Excision of the nail root in paraeponychia. Note the small hook used to elevate the corner of the nail.

is wise to err on the radical side of the removal. In fact, when there is an eponychial subungual abscess it is wiser, in most cases, to remove the root of the nail all the way across from one side to the other." At times this pro-

cedure will be unnecessary, it being necessary to remove only a small portion of the nail, but this is uncommon and is fraught with danger of repeated cutting of the nail and of unnecessary prolongation of the case. In the case of simple eponychia without a subungual abscess, the treatment will consist of merely cutting away the roof of the pus blister and the application of an ointment or wet dressing. In cases of severe paraeponychia it generally will be wise to remove the entire nail with the patient under general anesthesia. The distal attached portion of the nail is gently freed from the underlying matrix by carefully inserting under it a periosteal elevator or some other flat instrument. The nail is then grasped with a strong forceps and removed by a twisting motion (Fig. 393). It is very important to remove *all* of the nail with

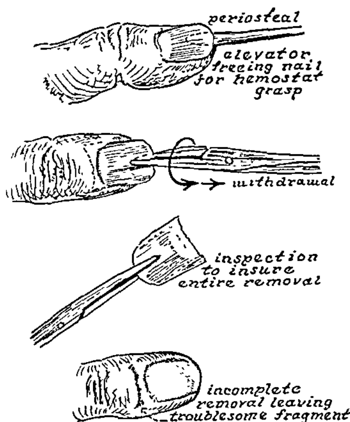


Fig. 393.—Technic of avulsion of the nail. It is separated from its bed with a periosteal elevator or flat instrument and seized with a hemostat and removed by twist and traction. It is inspected to make sure that all is removed. Incomplete removal of the nail leaves a troublesome fragment under the eponychium, and suppuration continues.

this procedure. If the nail is torn off so as to leave behind a small piece, the latter will act as a foreign body, and the suppuration will continue. Moreover, it must be emphasized that rough efforts to search for such a fragment or to curet under the delicate eponychium may cause permanent damage to the matrix. If the removed nail appears to be incomplete, the eponychium should be gently lifted up with a small hook and the offending piece removed under direct vision with a very small tissue forceps. "A little packing may be placed under the eponychium to hold it away from the nail bed for twenty-four to forty-eight hours and thus favor drainage." (Koch) This is considered important by Raison;[10] however, it is not always needed. Le Seur[11] advises never to incise the matrix of the nail longitudinally, because it leaves a split

nail.[12] A dressing with sulfonamides in carbowax (formula given in previous section) and petrolatum gauze is useful.

Felon or Whitlow.—The term felon has been applied to a variety of infections involving the distal portion of the finger. It commonly follows a trivial injury. Meticulous first-aid treatment of minor injuries of the finger tips will in many cases prevent the occurrence of a felon. The connective tissue of the distal phalanx forms a closed sac which includes the diaphysis of the bone. Fibrous septa run vertically from the palmar surface of the skin and divide this sac into several chambers. Infection which develops in these spaces tends to remain there because of the thickness of the palmar skin or else very early to attack the bone itself. In the words of Berman and Strahl:[13] "The distal four-fifths of the phalanx is a closed space, and together with the diaphysis receives its blood supply from two digital arteries which are found on the anterolateral aspects of the bone. The epiphysis is supplied by the digital arteries before they enter the closed space. If, therefore, inflammatory exudate occurs therein, it cannot escape at all freely, so that when tension obstructs the blood supply, necrosis of the diaphysis is caused. Even after union of the epiphysis and diaphysis, necrosis is generally limited to the diaphyseal region, the base remaining intact except in late, neglected cases." The term includes those infections which are centered in or beneath the periosteum of the distal phalanx, abscess formation of the pulp of the finger pad above the periosteum and collar button abscesses of the finger tip. It is extremely important to make an early diagnosis. This may present considerable difficulty. There may or may not be an external wound. It is possible that some slight blow upon the finger tip may bring about a *locus minoris resistentiae* where organisms brought by the blood stream from a distant focus will settle and propagate. A very trivial wound, such as a pin prick or a thorn prick, may be the cause of a felon. The characteristic symptoms of a felon are: first, extreme pain; second, swelling; third, throbbing pulsation; and fourth, tenderness of the phalanx itself. The patient will report that he gradually has been having an increase of pain in his finger tip which has become so severe as *to interfere with his sleep*. The affected finger tip will be somewhat red, will be swollen and will be extremely sensitive to palpation. A careful painstaking examination generally will elicit the fact that continued palpation of the tip of the distal phalanx is extremely painful, although the maximum redness and inflammation will seem to be at a point somewhat removed from there. This tenderness of the bone itself is suggestive of early osteomyelitis or periostitis. It may be further elicited by a squeezing pressure of the base of the distal phalanx.

Once the diagnosis of felon has been established, prompt surgical treatment is indicated. Hot fomentations or inadequate small "medical incisions" will cause increased pain and will do actual harm. Radical free incisions should be made. As emphasized by Koch,[14] these incisions should be made with the patient under general anesthesia, such as nitrous oxide or ethylene. Koch says to "freeze such an infected area causes further injury of the tissues, and to infiltrate it with procaine may diffuse the infection still more widely. Neither method, moreover, gives satisfactory anesthesia because the pus under tension has rendered the sensitive finger tip abnormally hyperesthetic. If nitrous oxide or ethylene is not available, the digital nerves at the base of the finger should be blocked with procaine."

The best incision for the drainage of a felon is that of Koch[14] shown in figure 394. Koch says that this incision suffices if "it is long enough and if the knife is made to sweep across the palmar surface so as to divide the fibrous septums that pass vertically from the skin to, but not into, the perios-

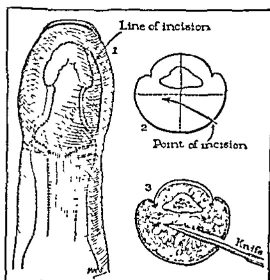


Fig. 394.—Incision for drainage of a felon. (Koch, S. L.: J. A. M. A. 92: 1171, 1929.)

teum. The incision should not extend upward far enough to permit invasion of the sheath of the deep flexor tendon at its insertion on the base of the distal phalanx. The horsehoe-shaped incision so frequently advised is unduly long in healing and leaves a painful scar over the finger tip and an anesthetic area

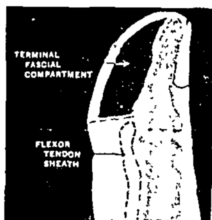


Fig. 395.—The terminal fascial compartment in the pulp of a finger or thumb. Incision for an infection should never extend proximal to the limit of the compartment, because of the danger of invading the flexor tendon sheath, with the production of suppurative tenosynovitis. (Bailey, H.: Emergency Surgery, Baltimore, William Wood & Co, 1936.)

distal to the scar which is particularly annoying to anyone attempting to perform delicate manipulations." Bailey[15] says: "In infections limited to the pulp, to allow the incision to extend in a proximal direction any farther than half an inch from the terminal flexor crease is to break a surgical commandment by permitting the knife to enter hallowed ground." (See Fig. 395.)

During the making of the incision it is not uncommon to open a discrete abscess. Should this be the case, no further procedure is necessary other than the insertion of a rubber or vaselin gauze drain. Koch[14] says: "If the condition is recognized early there should not be any necessity for curetting or excision of the bone. Because the digital arteries are compressed by the pressure of the exudate as they pass through the closed space, and because there is a direct path through the columns of fat for the transmission of infection from subcutaneous tissue to periosteum, bone involvement does take place early, but it should not occur if the symptoms are correctly interpreted and the condition properly treated early in the course of the infection." Auchincloss advises the hockey stick incision. Incisions on the palmar surface of the finger are ill advised because of their inadequacy for drainage and because of the likelihood of subsequent tender scar formation. The finger is now enclosed in a copious boric acid dressing. The drain is usually not



Fig. 396.—Destructive osteomyelitis of the distal phalanx in a case of neglected felon. (Surgical Dispensary, Northwestern University Medical School.)

removed at the first or second dressing but is allowed to remain until it either comes out by itself or can be withdrawn without much pain. The drain should not be replaced. The hand should be placed at absolute rest with a splint or in a sling at least. Penicillin or sulfonamides are usually excellent supplementary aids.

It is not uncommon in cases of felon to have necrosis of the distal phalanx (Figs. 396, 397). Small fragments of bone may spontaneously extrude themselves from the wound. In a case of active osteomyelitis of the distal phalanx, the bone should not be curetted or otherwise traumatized. The sequestrum generally will be extruded spontaneously. If it is entirely detached from the bone, it may be lifted out of the wound, the opening being enlarged slightly if necessary. In a case of neglected felon the entire diaphysis may be involved, with resultant shortening of the finger. Even with early diagnosis and prompt treatment it may be impossible to prevent the loss of a small fragment of a necrotic bone, and the patient should be acquainted with this danger at the

outset of the treatment. Berman and Strahl[13] say that "infection of the distal phalanx undergoing necrosis with complete destruction of the diaphysis and even as much as seven-eighths of the epiphysis involved, will have a tendency to go on to complete bone restoration of the phalanx, if suitable drainage is instituted and sequestra removed.

"The removal of sequestra hastens restoration; the nonremoval will cause delay in waiting for them to be discharged from the wound, and may destroy neighboring healthy tissue."

Koch[16] says: "The essential factors in the treatment of osteomyelitis of the bones of the hand are adequate drainage of the overlying soft parts, cleanly surgical care, and avoidance of trauma—by irritating chemicals, by addition of infection from without, and, particularly, by the use of curette and chisel. If death of bone takes place a line of demarcation forms and the necrotic bone, if it is not extruded spontaneously, can be removed without trauma. To attempt to determine a line of demarcation by surgical intervention too frequently results in destruction of living bone and extension of infection, and often makes recovery of the affected bone impossible." (See section on osteomyelitis.)

Suppurative Tenosynovitis.—The modern conception of the pathologic anatomy and treatment of hand infections is practically all based upon the

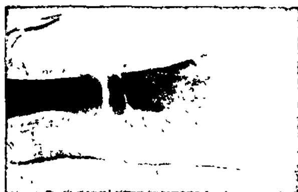


Fig. 397.—Osteomyelitis of the distal phalanx following a felon. (Compare with figure 413.)

pioneer work of Kanavel, and to him must be accorded credit for our better understanding of this subject. The tendon sheaths may become infected through the introduction of organisms, generally the staphylococcus, by wounds and, less frequently, by direct extension of the infection from neighboring parts; rarely are they metastatic in origin. Wounds which cause the introduction of pathogenic organisms into the tendon sheath are generally of the puncture or stab variety. Wounds caused by can openers, nails and sharp-pointed knives are particularly culpable. Tendon sheath infections are extremely serious because of the rapidity of their spread and because of the likelihood of destruction of the tendon sheath or of the tendon itself. A few hours after the infection of the sheath the patient will experience pain and tenderness of the part involved. After twenty-four hours or more the disturbance will be very marked, and it is imperative to make an early diagnosis.

The three cardinal symptoms of tenosynovitis, according to Kanavel, are as follows: (a) exquisite tenderness over the course of the sheath and limited to the sheath; (b) flexion of the fingers; (c) exquisite pain on extending the finger, this pain being most marked at the proximal end of the finger. The entire finger is swollen and painful. The diagnosis may offer some difficulty. The

test devised by Moses,[17] which he considers specific, is as follows: "The nail of the involved finger is engaged in the thumb nail of the examiner in such a manner that *actual* flexion (and thereby compression of the soft tissues) is not allowed. The patient is then asked to *attempt* flexion of the member. It will be seen in the accompanying photograph (Fig. 399) that the examiner's



Fig 398.—Infection of the finger following a bite. Note the lateral incision for sheath infection.

forefinger may be used to steady the dorsum of the finger. In the presence of acute tendon sheath infection, acute pain is experienced along the palmar aspect of the finger due to the bowstringlike tensing of the tendon against its sheath. Pain is consistently absent in infections involving the soft parts alone." Suppurative arthritis of the interphalangeal or metacarpophalangeal joints



Fig. 399.—Actual flexion of the involved finger is prevented by the engagement of the nail of the finger in the thumb nail of the examiner. Attempted flexion produces pain along the palmar aspect of the finger in the presence of acute tendon sheath infection. (Moses, W. R.: Surg., Gynec. & Obst. 82: 101, 1946)

will cause pain on movement of the joint, but the localized tenderness in these cases will generally make the differential diagnosis easy. If the tendon sheath is not widely opened and drained, the pus which forms under pressure and which is limited to the rigid envelope of the sheath will spread along its extent and will invade various other structures according to what sheath is involved. The tendon sheaths of the index, middle and ring fingers extend

from just beyond the distal flexion crease of the finger to a line which closely approximates the distal palmar flexion crease. The sheath of the long flexor of the thumb begins at a point slightly distal to the distal flexion crease of the thumb and accompanies the flexor pollicis longus through the palm to terminate a thumb's breadth above the anterior annular ligament in an expansion known as the radial bursa (Fig. 400). (Koch) The tendon sheath of the flexors of the little finger begins just distal to the distal flexion crease of the fifth finger and extends proximally to become continuous, in the majority of cases, with the ulnar bursa, a good-sized sac which lies over the metacarpal bone of the ring finger and the head of the middle metacarpal bone and extends proximalward under the anterior annular ligament a thumb's breadth above the ligament (Fig. 400). (Koch) Because of the occa-

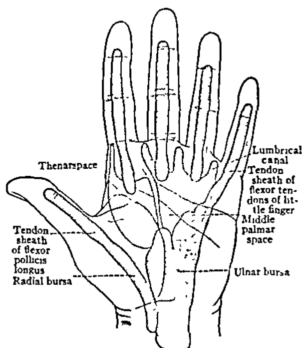


Fig. 400.—Diagram showing the position and extent of the flexor tendon sheaths and of the fascial spaces of the palm. (After Kanavel.) (Koch, S. L., in Christopher, F.: Textbook of Surgery, ed. 4, Philadelphia, W. B. Saunders Co., 1945, p 166.)

sional communication between the ulnar and radial bursae, infection from the thumb may extend to the little finger without involvement of the index, middle, and ring fingers. The possible extension of infections of the various tendon sheaths is indicated in the following table, made from the studies of Kanavel. Kanavel injected the tendon sheaths with a visible injection mass under varying degrees of pressure and traced the extensions of this injected mass.

Possible Extensions of Infections from Various Sites in the Hand (After Kanavel)

Site of original infection.	*Possible extensions.*
1. Thumb..........	In the majority of cases the pus ruptures from the sheaths of the flexor longus pollicis into the forearm. Rarely invades the thenar space. May involve dorsal subcutaneous tissue.
	By synovial sheath extension to thenar space.

2. Index finger......Subcutaneous tissues of dorsum of hand. Rarely middle palmar or thenar spaces (fascial space extension). By synovial sheath extension to the thenar space.
3. Middle finger.....Synovial sheath extension to the middle palmar space, exceptionally the thenar space.
4. Ring finger.......Synovial sheath extension to middle palmar space.
5. Little finger......By tendon sheath extension to middle palmar space, or if continuous with ulnar bursa to the forearm.

The common error in the treatment of tendon sheath infections is the withholding of adequate incision until the pus has burrowed to some distant extension of the sheath or has burst through the sheath and caused a considerable amount of damage. It is extremely important *in all cases of infection* of the hand not to be content with hot fomentations unless a vigorous effort has been made to exclude the presence of tenosynovitis. The treatment of tenosynovitis is the wide opening of the tendon sheath along all the part of it which is involved in the infection. It is far better to open a few tendon sheaths too early than one too late. (Auchincloss) The correct incisions for opening these sheaths are indicated in figure 401. In general, it may be said that incisions in the finger should be at the lateral margin and should be limited to the individual phalanges, that is, they should not cross the flexor creases of the volar surface of the finger. It is generally advisable to have incisions on both sides of the finger which enter the tendon sheath and permit bilateral drainage. The incisions are best made with the patient under general anesthesia and in a field which has been rendered *bloodless by means of a blood pressure machine tourniquet.* The digital nerves should be avoided if possible. The incisions for the radial and ulnar bursae will follow the general course of these structures. When the pus has escaped from a radial or ulnar bursa and has passed beneath the annular ligament of the wrist into the forearm, the maximum accumulation of pus will be beneath the flexor tendons and at an area 2 or 3 inches above the wrist joint. Lateral incisions into the forearm should be made on both sides in this area. Once the incision has been made, the margins of the wound should be held open by light gauze packing or rubber tissue drain or, perhaps best of all, a small piece of split rubber tubing may be sutured with plain catgut into the depths of the wound. Koch says that "the use of through-and-through drainage above or underneath a flexor tendon should be carefully avoided. It is the surest possible method of causing necrosis of the tendons." Bunnell[18] says that hand incisions should be "well chosen and of adequate size." They "should not sever the pulleys in the fingers, nor cut the nerves in the fingers or palm, especially the motor thenar. The most pernicious, and unfortunately the one usually made, is the median longitudinal, whether in palm, wrist, finger, pulp, matrix, or dorsum of the finger. It wrecks the hand, causes flexion contractures by being at right angles to the flexion creases, cuts the pulleys, places roughening and adhesions along the worst place, viz., the gliding surfaces of tendons, and is poor for drainage. In fingers, incisions should be midlateral and not anterolateral, as often pictured, where they will cut the nerves, and never should be midline. In the hand they should follow as much as possible the natural creases." Flynn[19] has found that sulfonamides, with sulfadiazine in particular, when used at an early stage, parenterally and locally, are of real value in decreasing the incidence of severe complications. "Drains should not be left in over two days and large hot compresses of boric acid with 0.5 per cent sodium

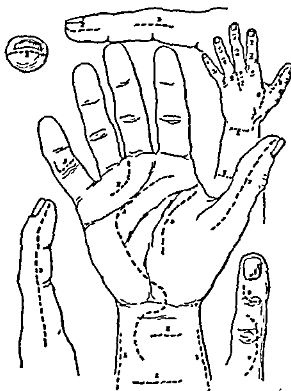


FIG. 401.—"*A chart of advisable or correct incisions in the hand which will afford access and will not cause disability.*" (Bunnell.)

"*A.* Incision for approach into palm for drainage of middle palmar space. It parallels the flexion creases, except in the immovable part or heel of the hand, allows wide opening by a triangular flap and can be prolonged so as to separate without severance the branches of the median nerve from those of the ulnar nerve. It then may be extended up through the annular ligament at its ulnar edge and up the forearm, as shown. It crosses the flexion crease in the wrist in a curve so as to avoid resulting in flexion contracture.

"*B.* Incision for draining thenar space. It parallels the thenar space, must not sever the thenar motor nerve and must leave pedicles sufficiently wide to nourish the area of skin between it and incision for middle palmar space abscess.

"*C.* Incision for part of thenar space dorsal to adductor muscles of thumb It should be radial to the first interosseus muscle and stop short of cutting the radial artery as it passes through the first cleft.

"*D.* Midlateral incisions in fingers and thumb which avoid volar nerves and vessels and do not produce flexion contractures. If made intermittently opposite the joints the annular ligaments or pulleys which are opposite the centers of the phalanges will be spared.

"*E.* Incision for drainage of pulp abscess. One should cut across lateral fat columns, be posterior to tactile surface, and not cause tenosynovitis by nicking the sheath of the flexor tendon.

"*F.* Flap incision for approach to extensor tendon in finger, so that the incision will be remote from the tendon.

"*G.* Incision for approach to insertion of extensor tendon.

"*H.* Palmar approach to collar-button abscess to give open drainage. Avoid cutting nerve to finger.

"*I.* Dorsal approach to posterior part of collar-button abscess. It does not overlie the joint or tendon.

"*J* Flap incision for subcutaneous abscess. One arm should be median to nerve; the other blocks the upward progress of the infection.

"*K.* Incisions in forearm for reaching tendons should parallel the fine wrinkling of the skin to be inconspicuous eventually and to avoid keloid formation.

"*L* Incision for drainage of quadrilateral space in forearm. Entrance should be just anterior to bones and anterior to the radial nerve and posterior to the dorsal branch of the ulnar nerve " (Bunnell, S.: J. Bone & Joint Surg. 14: 27, 1932.)

citrate, together with local and bodily rest, should follow. If kept too long, hot compresses overstimulate granulations and cause adhesions. After about

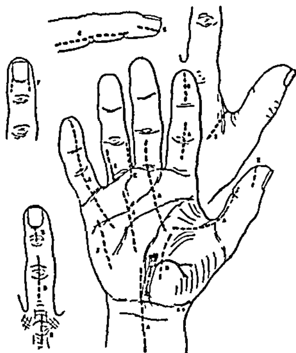


Fig 402.—"*A chart of pernicious or incorrect incisions in the hand, any of which will do harm.*" (Bunnell.)

"*A.* Median longitudinal incisions which cross flexion creases at right angles and result in flexion contractures. These are prevalent but pernicious.

"*B.* Median incision on dorsum of finger which later leaves a scar that contracts and hinders flexion of the fingers. When present, it is impossible to fashion a proper skin flap under which to repair the extensor tendon.

"*C.* Anterolateral incision in finger which is directly over and endangers the vessels and nerve. It is the usual one pictured for draining tendon sheaths, but should instead be midlateral.

"*D.* Incision which thoughtlessly severs the motor thenar nerve and so robs the thumb of the power of opposition.

"*E.* Median longitudinal incision through matrix will produce a ridged nail.

"*F.* Incisions for paronychia often pictured, but erroneous, as they do not drain the bottoms of the clefts formed by the borders of the base of the nail which curve strongly forward.

"*G.* Median longitudinal incision in pulp for drainage of a felon. It will not drain, as due to cleavage planes the pus progresses in spite of it and points dorsilaterally. Also, the scar resulting is in the tactile surface

"*H.* Alligator-mouth incision wrongly placed too far anteriorly which leaves a scar in the tactile surface.

"*I.* Incision across a web injures the web which itself has a function of complicated foldings to allow for movements of thumb.

"*J.* Incision often made for drainage of pus in sheath of tendon to little finger. The tendons, however, converge sharply in palm to pass between the ridge of the trapezium and the unciform process of the unciform bone.

"*K.* Incision continuous from finger to palm severs nerve, thus rendering half of finger permanently anesthetic." (Bunnell, S.: J. Bone & Joint Surg. 14: 27, 1932.)

a week, baths are used. These help active motion which should now be encouraged. . . . As healing progresses, the hand should be kept, when not exercising, in a functionating position by splints, with the wrist cocked up, proximal

finger joints flexed, and thumb in opposition."[18] Penicillin often is useful. Chemotherapy, however, cannot supplant surgical drainage but is an excellent supplement. The institution of hot boric acid fomentations (see Fig. 18) or hypertonic magnesium sulfate dressings will facilitate drainage from the wound. The extremity is placed at rest either on a pillow or splint or in a sling. The dressings are done with strict aseptic precautions to avoid mixed infection. As the purulent discharge diminishes, early active motion of the fingers and hand is cautiously instituted. The prognosis in cases in which surgical treatment is employed is excellent. In cases in which a proper diagnosis has not been made or in which surgical treatment has been delayed, very serious results may occur. A far wider area of the involvement is to be expected, the pus may spread outside the tendon sheath to the fascial spaces, or it even may involve the bones and cause osteomyelitis. The loss of a finger or even of a hand is not uncommon. Even if this unfortunate eventuality is avoided, the sloughing and loss of portions of tendons may occur with resultant loss of function of the finger. Should ankylosis of a finger become

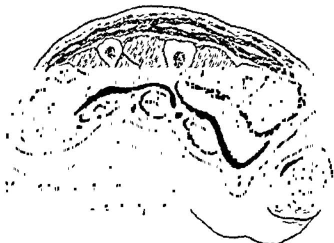


Fig. 403.—Cross section of the hand above the metacarpophalangeal joints to show the relation of the thenar and middle palmar spaces to the surrounding tissues. (After Kanavel and after Koch, S. L.: J. Indiana M. A. 21: 137, 1928.)

inevitable, the position of half flexion is the optimum for use and comfort. Ankylosis in extension produces a practically valueless finger. In a review of 125 cases of acute suppurative tenosynovitis of the flexor tendon sheath of the hand, Grinnell[20] found that there was gross sloughing of the tendons in whole or in part in 52 per cent of the cases. Only one-sixth of the patients regained approximately full function. The end-result in over a third of the cases was bad.

Fascial Space Infection.—The hand contains five principal fascial spaces, which are subjected to infection by puncture wounds or by direct extension from tendon sheaths, bursae or adjacent soft parts.[21] The *middle palmar space* may become infected by extension from the middle, ring and little fingers, the ulnar bursa or the lumbrical canals, by osteomyelitis of the middle and ring metacarpals or by direct implantation. In this condition there is marked swelling of the palm, so as to cause a loss of concavity. There is extreme tenderness in the palm and marked swelling of the dorsum. If this condition is neglected, there is likely to be spread of the infection to the

forearm. The treatment is adequate surgical incision and drainage. Th of incision best suited to this operation is indicated in figure 401. Th and through drainage to the dorsum of the hand never should be c out.

The *thenar space*, which lies upon the abductor muscle of the thum is partially covered by the short muscles of the thenar eminence, b flexor tendons of the index finger and by the accompanying digital v and nerves (Koch), may be infected by extension of the infection fro index finger and thumb, by direct implantation or by osteomyelitis o index and thumb metacarpal (Figs. 400 and 404). There is tendernes the area of the thenar space. Infection of the thenar space is likely to spr the forearm. The treatment is proper incision and drainage (Fig. 405).

The *hypothenar space* is generally well localized, and infection of it is quite unlikely to spread either to the forearm or to the adjacent structures. The treatment is incision and drainage.



Fig. 404.—Thenar space abscess. (Surgical Dispensary, Northwestern University Medical School. Courtesy of Drs. John A. Wolfer and M. L. Mason.)



Fig. 405.—Hand infection with invol of the thenar space in a diabetic p

The *dorsal subcutaneous space* and the *dorsal subaponeurotic spa* well localized and are not particularly susceptible to extension of inf In the case of the former the incision necessary for drainage does no to be as deep as for the latter.

The possible extensions of infections from fascial spaces, accord Kanavel, are the following:

(*a*) Palmar space: Under annular ligament of the wrist to the fo
(*b*) Thenar space: To dorsum of the hand, rarely if ever to the fo
(*c*) Hypothenar space: Does not communicate with any large spac
(*d*) Forearm: Largest part of the space is 2 inches above the wrist. Inf of fascial spaces without involvement of tendon sheaths generally

kindly with ordinary incision and drainage. When the tendon sheaths also are involved, these must be treated according to the principles just laid down. The wounds made in the treatment of hand infections are lightly packed with gauze impregnated with petrolatum. Copious hot boric acid fomentations are added. (See Technic of Hot Wet Dressings.) Best[22] says that in tendon sheath or fascial space infections, drainage material is often not necessary but that when it is to be employed, a thin rubber dam or a piece of rubber glove should be used.

Epitrochlear Lymphadenitis.—As indicated previously, the epitrochlear glands become enlarged following lymphangitis and other infections involving the little and ring fingers. Occasionally these lymph nodes will become large,

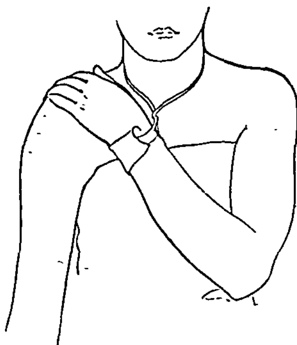


Fig. 406.—The Robert Jones necklace and wrist sling for the treatment of tuberculous elbow. (Allison, N.: Orthopedic Surgery, in Nelson Loose-Leaf Surgery, New York, Thomas Nelson & Sons, 1927, vol. 3.)

red and tender, and fluctuation eventually will become apparent. When the lymph nodes break down in this manner, incision and drainage are indicated.

For specific infections involving the hands see chapter II on open wounds.

Tuberculous Tenosynovitis.—Tuberculous tenosynovitis "is characterized by the insidious development of a slowly progressive, painful or painless swelling over the anatomic area of the involved sheaths. In one third of the cases the swelling is preceded by sensory or functional disturbance, such as pain, tingling, numbness or prickling sensations or by stiffness in one or more fingers. These premonitory symptoms may persist for many weeks or months before the actual swelling appears. A leathery crepitus, as in traumatic tenosynovitis, may occasionally usher in the tuberculous process. The swelling often appears as a sudden diffuse edema which responds to heat and rest only to be replaced later by the more tense localized swelling."[23] In one type of chronic tuberculous tenosynovitis the tendon sheath is lined with edematous granulation tissue and is only slightly tender. In the other type there is

passive effusion into the synovial space with some thickening of the lining membrane. "The treatment of choice is surgical excision of all diseased tissue." (Mason[24]) In all cases of tuberculous tenosynovitis the patient is given treatment for his systemic tuberculosis (fresh air, food, rest, etc.).

Tuberculosis of Joints.—Tuberculosis rarely involves the joints of the upper extremity. The elbow is most commonly involved. It is characterized by swelling, pain, limitation of motion and the characteristic *x*-ray findings. There may be muscular atrophy. The body temperature is elevated, and there is history of chronicity. Evidence of tuberculosis elsewhere in the body, generally, will be found. Systemic treatment of the tuberculosis is first indicated. According to Allison,[25] early excision gives the best results in adults. In children, "careful protection of the diseased elbow for a long period of time is the only treatment for the local disease." (Allison) For this purpose the Robert Jones necklace and wrist sling is very useful (Fig. 406). Tuberculosis of the wrist joint is characterized by swelling, heat and stiffness. The treatment



Fig. 407.—Tuberculosis of the fingers (spina ventosa). (Surgical Dispensary, Northwestern University Medical School. Courtesy of Dr. M. L. Mason.)

is directed toward the general condition and also immobilization of the wrist on molded plaster splints. Excision of the joint is performed in cases of severe involvement.

Tuberculosis of the Phalanges (Spina Ventosa), Tuberculosis Dactylitis.—In this condition there is swelling of one of the phalanges due to tuberculosis of the shaft (Fig. 407). The child holds the finger stiff, but it is not particularly painful. There is necrosis of bone with sequestrum and involucrum formation. The *x*-ray examination is important. Rest of the finger and measures directed toward improving the general health may effect a cure in the early cases. In the later cases the dead bone should be removed by operation and the finger put at rest in a splint.

Mensor[26] reports a case of fracture of the carpal navicular bone which, after removal, was shown to be tuberculous by microscopic examination and guinea pig inoculation.

Osteomyelitis.—Although only about 11 per cent of cases of osteomyelitis involve the upper extremity, the general discussion of that subject will be taken up at this place. The distribution of 385 separate osteomyelitis lesions

was reported by Klemm[27] as follows: femur, 111; tibia, 101; humerus, 27; os ilii, 26; fibula, 23; calcaneus, 19; skull, 11; radius, 8; ulna, 8; metatarsals, 8; talus, 8; clavicle, 7; sacrum, 6; vertebrae, 4; sternum, 3; ribs, 3; scapula, 3; os pubis, 2; os ischii, 2; phalanx man., 2; os cuboideum, 1; phalanx ped., 1, and metacarpus, 1.

Acute Osteomyelitis.—In most cases of acute osteomyelitis, there is hematogenous origin. However, it must be remembered that osteomyelitis may occur as a complication of a compound fracture,[28] amputations, empyema, felons, abscessed teeth and the insertion of metal bone plates or screws. In the words of Hart:[29]

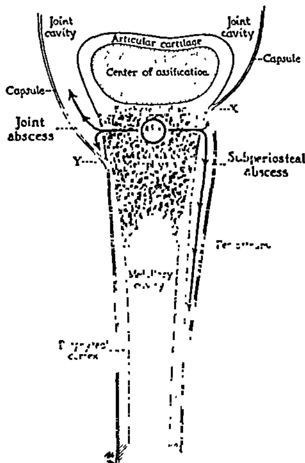


Fig. 408.—Diagram illustrating the usual course of spread of infection in acute hematogenous osteomyelitis. *X* represents the point of firm attachment of capsule and periosteum in the region of the epiphyseal disk when the metaphysis is extracapsular. *Y* is the fixation point of capsule and periosteum when the metaphysis is intracapsular. (Hart, V. L.: J. A. M. A. 108: 524, 1937.)

respiratory regions. A bacteremia necessarily precedes the localization of infection in the osseous system. Cultures of blood and pus demonstrate that the most common infective agent is Staphylococcus aureus. Staphylococcus albus, Streptococcus pyogenes and pneumococcus organisms are also frequent causative agents.

"The first skeletal manifestation of the disease is constantly localized in a single metaphysis of one of the long bones of the extremities (Fig 408) or in the juxtaepiphyseal region of other bones of the growing skeleton. The primary bone involvement is not in

the medullary cavity or cortex of the main shaft of a growing bone. During the early acute stage of the disease the infection is limited to a single metaphysis. However, subsequent to direct or hematogenous spread of the infection and in the subacute and chronic phases of the disease the main shaft, the neighboring joint and the medullary cavity may be affected. If the infection is not in the main shaft and medullary cavity during the acute stage there is no reason for their surgical exposure. The surgical attack should be limited to the site of the infection or metaphysis."

Green and Shannon[30] found that "Staphylococcus aureus was the offending organism in 91 per cent of a series of cases in older children (from 2 to 12 years) observed in this hospital; however, in the group of infants, Streptococcus haemolyticus was by far the predominant organism." In a group of 76 infants (children under 2 years of age) "staphylococcus was found to be present in 22 cases, or 30 per cent; of these, Staph. aureus was present in all except 2, in which Staphylococcus albus-haemolyticus was present. These were 3 cases in which pneumococcus was present and 1 in which the gonococcus was identified by smear and by culture."

"The main cause of osteomyelitis is the Staphylococcus, and its chief habitat is the skin. Bacteria enter the blood stream from the skin focus and lodge in the bones." (Phemister) Boils and all other types of cutaneous pyogenic infections are important etiologically.

Eikenbary and LeCocq[31] reported 3 cases of *osteomyelitis variolosa* and conclude that the "virus of small [illegible] eomyelitis," and that "site of election of [illegible] the long bones." An aseptic necrosis is [illegible] epiphyseal lines and causes deformities by inequality of growth. Multiple foci of osteomyelitis due to typhoid have been reported.[32]

Robertson[33] believes that trauma plays an important etiologic role, but doubt is cast upon this statement by the fact pointed out by Phemister that so few patients with fractures acquire a hematogenous infection. Pyrah and Pain[34] found the mortality in 262 cases of acute osteomyelitis to be 27.1 per cent.

Patients with acute osteomyelitis may be divided into three separate age groups (under 2, 2 to 12 and over 12 years of age). For each age group there are somewhat different etiologic factors, clinical manifestations and required treatment. Moreover, within each group the symptoms are variable. The disease in infants (under 2 years), according to Ober,[35] is manifest by the following:

"a history of acute, sudden onset usually attended by a severe constitutional reaction, characterized by high fever, rapid pulse, restlessness, loss of appetite, irritability, delirium and great prostration Dry skin, sunken eyes, blueness of the facies or extreme pallor, general tenderness on handling, which may be localized finally in the affected part, are also [illegible]

[illegible] the fluid, however, contains no organisms. A careful examination will reveal *swelling and tenderness* over the end of the diaphysis. If there is doubt, the joint may be aspirated. It is wiser to aspirate a joint to help make the diagnosis than to do an arthrotomy and find a simple synovitis. Otherwise one is forced to open up an abscess in close proximity to the joint and then have the joint become secondarily infected from the osteomyelitic process."

In children 2 to 12 years of age the symptoms are similar to those in children under 2, but generally they are somewhat less fulminating. Of acute osteomyelitis in adults, Zadek[36] says, in part:

"1. Acute osteomyelitis of the long bones of adults presents a picture different from that usually seen in children. 2. The onset is insidious, and development of the lesion is gradual in all but exceptional cases. 3. The pain is not so acute as in children and not so well localized. Pain is the most constant symptom and usually after many days or weeks is extremely acute. 4. The roentgenographic picture is different from that in children and may be confused with that of endothelioma. 5. The temperature and the blood cell counts are not so high as one might expect. 6. The lesion involves principally the marrow and the periosteum. There are spotty atrophy of the cortex and formation of light new periosteal bone if the lesion is in the shaft. 7. The lesion tends to be localized, without formation of sequestrums or involucrums. 8. Operation is indicated as soon as one suspects the presence of acute osteomyelitis."

Leukocytosis (20,000–40,000 cells) is the rule, but the writer has seen a patient with osteomyelitis with a normal white blood cell count. There may be a positive blood culture. *x*-Ray examination is of no value before the fifth to fourteenth day in making the diagnosis of osteomyelitis.

The treatment of acute osteomyelitis varies with the age and the general condition of the patient. Twenty-five years ago it was always considered a surgical emergency. Now it is realized that the mortality is considerably less if conservative treatment is employed when the patient is toxic until his resistance is at the highest possible point. Miller and Smith-Petersen[37] say that "no local operation should be undertaken until the patient's condition warrants it." Brown[38] studied 160 cases of acute hematogenous osteomyelitis of the long bones in children and young adults and concluded that "immediate operation with opening of the bone, whether by gouge or drill, upon diagnosis of acute osteomyelitis in an acutely toxic patient, is accompanied by an *unjustifiable mortality and should the patient survive, it is probably* in spite of, rather than because of, surgery."

With the advent of chemotherapy, the treatment of acute osteomyelitis has become revolutionized. Penicillin has been shown to play an outstanding role, with the sulfonamides having a less important, secondary part. Altemeier and Helmsworth[39] say: "There seems to be little doubt that early and ae-d quate penicillin therapy can eliminate the necessity of surgical intervention in cases of acute osteomyelitis." These authors summarize their study as follows:

"During the past 21 months 34 cases of acute osteomyelitis in which patients were treated with penicillin have been studied and a preliminary report of the results has been presented. If the diagnosis was made early and penicillin treatment instituted promptly without surgical drainage, both the general and local infections were brought under control so thoroughly that a minimal amount of residual bony damage resulted. Moderate delay in diagnosis and treatment increased the extent of bony damage, but the infection was nevertheless quickly arrested without the aid of drainage and without sequestration. If small localized abscesses developed, they were treated very satisfactorily by aspiration followed by injection of a solution of penicillin. If large abscesses developed, prompt drainage by surgical incision was required. Delay in diagnosis and treatment not only increased the degree of bony damage, but favored the development of large abscesses, sequestra, and metastatic visceral infections.

"A period of 36 or more hours after onset of penicillin therapy usually occurred before the beginning of definite clinical improvement even in the cases diagnosed early. Occasionally cases of acute osteomyelitis are seen

which are so fulminating that they will not survive the 48 or more hours necessary for the full effect of penicillin. Such cases must be recognized early during penicillin therapy and subjected promptly to the surgical procedure indicated.

"Penicillin is a powerful and effective chemotherapeutic agent in the treatment of acute osteomyelitis. When administered early and in adequate amounts, it reduces the mortality and morbidity, brings the infection under control, minimizes local destruction of bone and resultant deformities, permits spontaneous removal of necrosed bone and healing, and makes possible early return of normal or nearly normal function."

Compere and his associates[40] report the successful use of penicillin in twelve cases of acute hematogenous osteomyelitis in children aged 3 to 12 years. In ten of these cases the infection was resistant to the sulfonamides. Operation was necessary in four cases: in one, for the removal of a small sequestrum, and in three for the drainage of an abscess after the acute infection had subsided. The authors advise that 15,000 to 20,000 units of penicillin be administered intramuscularly every three hours day and night. As the temperature declines, the size of the dose may be decreased, but the frequency must be maintained.

Kenney[41] says:

"The mortality in acute hematogenous osteomyelitis before chemotherapy was 23 per cent on the average, 46 per cent in the toxic cases, and around 3 per cent in the nontoxic cases. After sulfonamide the mortality was 3.5 per cent."[42]

Key[43] says: ". . . when a patient is suspected of having acute hematogenous osteomyelitis, this patient is a surgical emergency and he should be seen by a surgeon at the earliest possible moment and taken to the hospital immediately. When he enters the hospital he should be given a full dose of sulfathiazole by mouth or of sodium sulfathiazole intravenously and his general condition should be estimated. If he is exhausted and dehydrated, he should be given ample sedation and ample intravenous fluids. If he is extremely toxic he should be [illegible] laid down by [illegible] put at rest for [illegible] can be correc[illegible] [illegible] he anesthetic is started, [illegible] l anesthesia. As a rule, [illegible] wise to traumatize the limb by the tourniquet. The bone in the suspected area should be exposed by the most direct route with as little damage to the surrounding tissues as possible. The incision should be ample, but not excessive in length. Whether or not pus is encountered after incising the periosteum, the medulla of the bone should be opened. In younger patients in which the focus is near the end of the bone I use a sharp thin osteotome, cutting out a window with the corner of the osteotome. In older patients or in locations where the cortex is thick I first make multiple drill holes in the cortex and then connect these by cutting out the intervening bone with the osteotome. A small drill point is used first and this is followed by one about ¼ inch in diameter. Every effort is made to handle the bone as gently as possible and to avoid excessive pounding on the bone or a sudden increase in intramedullary pressure. It is to be emphasized that this operation is for drainage only and that no attempt is made to remove the infected and necrotic bone. If there is extensive disease in the medullary cavity and the patient is in good condition, a relatively long window is made in the cortex. After hemostasis has been effected, the wound is sprinkled generously with powdered sulfathiazole and is packed loosely with vaseline gauze and the extremity is immobilized either in a plaster-of-Paris cast or a very voluminous dressing and splint or by traction. The anesthetic is continued no longer than is necessary. Postoperatively the patient is given intravenous fluids and if the red blood cell count is low he is given repeated small

transfusions. Also, the large doses of antitoxin should be continued as long as the non-segmented leucocytes are relatively increased in the blood (over 20 per cent)."

Dickson and his associates[44] obtained primary healing in 82 per cent of 22 cases of subacute and chronic osteomyelitis in which treatment consisted of sulfathiazole orally, [illegible] Weller[45] [illegible] [47] is con- [illegible]

If immediate surgical treatment is contraindicated, the extremity should be immobilized and supportive treatment carried out. The prognosis for the extremity is unfavorable when the related joint is invaded or when the epiphysial cartilage is affected so that there is interference with subsequent growth. Occasionally amputation is necessary to save a life or to get rid of a useless leg.

If operation is decided upon in the case of an infant, adequate drainage of the fluctuant abscess, "without operation on the bone, seems to give as satisfactory results as a more extensive procedure. If the abscess is drained a prolonged search for the lesion in the bone should never be made."[30] If surgical intervention to the bone seems indicated, the least to accomplish the objective should be done; one or two drill holes should be sufficient. After operation, according to Green and Shannon: "Packing the wound open with petrolatum gauze combined with immobilization in a plaster cast is a desirable method of treatment. The cast should be bivalved to allow for dressings. The first dressing should not be made until ten days after the operation, thus allowing granulation tissue to line the wound. At that time dressing can be done painlessly. Dressings are done at weekly intervals thereafter with replacement of the petrolatum gauze. The part should be immobilized until the wound has healed and there is evidence of healing in the roentgenogram."

In children older than 2 years and in adults, most workers believe it is important to bring about adequate drainage of the focus within the bone. Key,[49] Ober[35] and Phemister remove small windows from the cortex of the bone. Starr[50] and others are content with drill holes. Miller and Smith-Petersen[37] say: "Local operation should be conservative. The soft part or subperiosteal abscess should be drained, and, if there is a definite suspicion of pus in the bone, a few drill holes may be made, but no widespread removal of bone substance should be attempted. The so-called saucerization or 'unroofing' of a bone cavity is best left until a later date." The bone is not curetted. In his five and one-half year survey, Crossan[51] noted the type of operation and the mortality in 775 cases: "Of these cases, 220 were treated by incisions, and in two reports it was mentioned that some of the cases were so treated because the patients were very ill; there were 31 deaths, a mortality rate of 14 per cent. In the remainder, 555 patients, the bone was drained and 118 or 21 per cent died. So it can be inferred from these figures that incision alone did not increase the death rate."

After operation the wound is packed with vaselin or vaselin gauze and immobilized in a plaster cast (Orr treatment). Loehr[52] advocates packing the wound with cod liver oil salve and the application of a plaster cast. Fraser[53] packs the wound with gauze soaked in liquid paraffin, acriflavine and 2 per cent sodium citrate; the citrate keeps the discharge in solution, the acriflavine is an antiseptic, and the paraffin permits easy removal of the

pack. Sulfanilamide[54] and blood transfusions are helpful in the postoperative period. The wound should be dressed infrequently: Orr[55] says three times in six weeks.

Chronic Osteomyelitis.—Those interested in the subject of chronic osteomyelitis must not fail to consult the papers by Baer[56] on the maggot treatment and by Kulowski[57] on the Orr treatment. Anderson and his associates[58] found penicillin to be useful in the treatment of 40 cases of osteomyelitis. Operative treatment was combined with the use of penicillin in 14 cases. The authors say:

"Primary closure following sequestrectomy or evacuation of an abscess of a bone is a safe and satisfactory procedure for patients who are receiving penicillin." Buchman and Blair[59] found penicillin to be ineffective in the treatment of chronic osteomyelitis when surgical measures were excluded. Grace and Bryson[60] have had excellent results in the treatment of chronic osteomyelitis with penicillin. They say: "Individual treatment consisted of hospitalization for a period of from ten days to three weeks with intramuscular penicillin (we have used both the sodium and the calcium salt) varying from 10,000 to 20,000 units every three hours. In some cases from 20,000 to 50,000 units were used for the first four doses. Simultaneously from 4000 to 20,000 units of penicillin per cubic centimeter was applied locally into the sinus tract with 1:1000 Aerosol O. T. (dioctyl ester of sodium sulfosuccinate) or Tergitol 4 (sodium tetradecyl sulfate) in isotonic solution of sodium chloride. The local application of penicillin to the site of infection was made at regular three hour intervals with quantities of solution up to 4 cc. retained in each sinus cavity either by drainage or with a compression bandage. The drainage method was accomplished by placing the patient in such a position that the sinus, from its cutaneous opening, would be uppermost, thereby allowing the solution of penicillin and wetting agent to seep down by gravity to the area of infected bone. When this was not possible, petrolatum gauze dressings were placed over the sinus after the solution had been injected."

For control of the odor in the Orr treatment of osteomyelitis, 18 per cent lactose in distilled water has been found useful.[61]

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59. [illegible]
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61. [illegible] Key, J. A.: [illegible] 944.

CHAPTER XX

TUMORS AND DEFORMITIES OF THE UPPER EXTREMITY

Ganglion ("Weeping Sinew").—A ganglion is a cystic tumor which usually occurs in proximity to a tendon sheath and joint and contains a thick mucinous or myxoid fluid. A *synovial cyst* and a ganglion may be slightly different modifications of the same condition. The clinical distinction between the two is often impossible.[1] Ganglions are most commonly found on the dorsum of the wrist (Fig. 409) but are also found on the volar surface of the wrist and at the angle, in the popliteal space and on the volar sufaces of the fingers and hand. Ganglions may also occur in the substance of a tendon. (Mason) The older idea that they are hernial protrusions has not been substantiated. Carp and Stout[2] believe that ganglions are "cysts resulting from mucinous degeneration of connective tissue" which do not communicate primarily



Fig. 409.—Ganglion of the wrist. (Moorhead, J. J.: Traumatic Surgery, ed. 2, Philadelphia, W. B. Saunders Co., 1923.)

with joints or sheath spaces. King[3] concludes that the process is not primarily a degeneration of cellular tissue but a secretion of the synovial cells. He believes that the chief causes are trauma and a constitutional factor. Certain authorities contend that they do communicate with tendon sheaths.

According to Mason:[4] "When fully developed the ganglion consists of one large cavity with no evidence of any connection between the cyst and the synovial space. In fact, the basal tissues upon which the cyst rests are thick and dense, part of the fibrous capsule or tendon sheath, and if we examine it carefully we find that it presents numerous cystic [illegible]

[illegible] of conjecture. Jensen[1] suggests that ganglions "have their origin in embryologic arrests in the process of the development of the periarticular tissue and synovial membranes."

Mason[4] believes that the best treatment of ganglion is complete excision. He says: "This must be performed in a bloodless field and by careful dissection. It is not sufficient to remove the cyst alone, but the tissues from which the ganglion springs must be excised since they contain other cysts or degenerative areas which are likely to lead to recurrence. Transverse incisions are much to be preferred to longitudinal ones for removal of the carpal ganglia. The transverse incision gives excellent access and, since it follows the natural skin folds, heals with a minimum of scar and contracture."

De Orsay, Mecray and Ferguson[5] obtained a cure in 15 of 18 cases (83 per cent) by excision (Fig. 410). In 102 cases of ganglion, Ghormley and

Cherry[6] found good results in 59 per cent with all methods of treatment. They advise complete surgical excision. *Roentgen-ray therapy was used* by Lyle[7] in 21 cases of ganglion; 1.5 erythema doses were administered immediately over the tumor once a month until results were obtained. If more than five treatments are necessary, the interval between treatments must be more than a month. In 17 of the 21 cases the results were good. The ganglion may be ruptured and dispersed by making it as prominent as possible and striking it smartly with a book. Caution must be observed that a carpal bone is not fractured.[8] After dispersion a snug bandage is applied for twenty-four hours. Carp and Stout[2] found 22 per cent and De Orsay and his colleagues[5] found 50 per cent of recurrences by this method. Sarma[9] believes simple but not

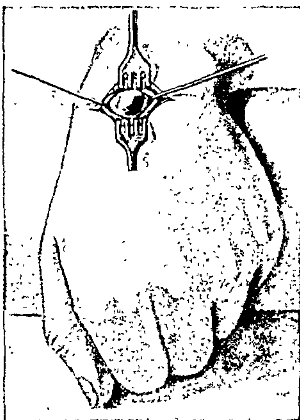


Fig 410.—Excision of a ganglion. (Kurtzahn, H.: Kleine Chirurgie, Berlin, Urban & Schwarzenberg, 1929.)

compound ganglions are suitable for injection treatment. With a 14 gauge needle, the ganglion is aspirated, and 5 per cent sodium psylliate or 5 per cent sodium morrhuate is injected, and a dressing and snug bandage is applied. By this method Sarma had 14 recurrences in 64 cases of ganglion (22 per cent).[10] Ganglion is most commonly found in females of slight build in the second, third and fourth decades. Trauma probably has little relationship etiologically. The ganglions range in size from that of a pea up to 2 or 3 cm. in diameter. They may be multilocular, and in the larger ones fluctuation may be elicited. When present on the dorsum of the wrist they may be made to appear more prominent by acutely flexing the hand. The conditions from which a differential diagnosis must be made *include tuberculosis of the*

joint and tendon sheath, lipoma, myxoma, fibroma, osteoma, sarcoma, bursitis and aneurysm.

McEvedy[11] cured 8 out of 10 cases of ganglion by aspirating the contents or expressing them through the needle and injecting into the ganglion from 0.5 to 2 cc. of a 5 per cent solution of sodium morrhuate. Bearse[12] has had no recurrences in 6 cases after simple aspiration of the sac with a large bore needle and a snug bandage applied for twenty-four hours. Welch[13] recommends transfixion of the ganglion with a cataract knife. Some will disappear spontaneously without treatment.

Epidermoid or Occlusion Cysts. (See also Epidermoid Cysts under Tumors and Deformities of the Head.)—Deep lacerated wounds of the fingers particularly, but also of the hand or arm, may bring about the displacement of small bits of epithelium into the depth of the wound. These isolated portions of epithelium have been known to grow in their new situation and to form cysts. In only 24 out of 55 cases, however, did Worz[14] find an adequate history of trauma. On the basis of experiments in which autogenous skin grafts



Fig. 411.—Traumatic epidermoid cyst. (Kurtzahn, H.: Kleine Chirurgie, Berlin, Urban & Schwarzenberg, 1929.)

were buried in the subcutaneous fat of human beings and later studied, Peer[15] believes "that the implantation theory of cyst formation in man is doubtful." These cysts may take many years to develop, and when excised, the lining will be seen to have an epidermoid or epithelial character. The diagnosis is made by the palpation of a rounded nodule in the subcutaneous tissues (Fig. 411). In 2 cases in which I operated, *x*-ray examination showed that the long-continued pressure of the cyst had caused a concavity in the adjacent bone (see Figs. 412–413).[16] The cyst may be slightly tender. The treatment of epidermoid cysts is their complete removal under local anesthesia.

Of interest is the case reported by Harris,[17] in which there was an epidermoid cyst of the terminal phalanx of the thumb. The end of the thumb was painful, and the preoperative diagnosis was a bone cyst.[18]

"Cutaneous horns," papillomas, fibromas and neurofibromas are small benign tumors originating in the upper layers of the skin. They may be readily removed under local anesthesia or by fulguration and do not tend to recur.[19] (See section on Warts.)

Granuloma is the term occasionally applied to an excessive or exuberant granulation tissue and is found in wounds where the rate of formation of granulation tissue exceeds that of epithelization. The granulation tissue ("proud flesh") projects above the wound surface and, unless removed, delays epithelization. This type of tissue is insensitive to pain and may be readily removed by simple clipping off with a scissors, after which the bleeding base may be cauterized with silver nitrate solution or stick. Small amounts of *excessive granulation tissue may be easily removed by cauterization with fused silver* nitrate.

Lipoma.—The diagnosis of lipoma has been referred to elsewhere. (See the section on Lipoma.) There generally is no necessity for the removal of lipomas except for cosmetic purposes. The writer has excised a lipoma from the volar fat pad of the distal phalanx of a finger and another from the palm at the base of the little finger.

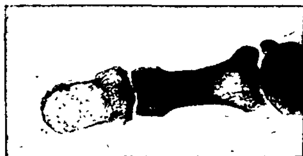


Fig. 412.—Epidermoid cyst causing pressure atrophy of the bone.

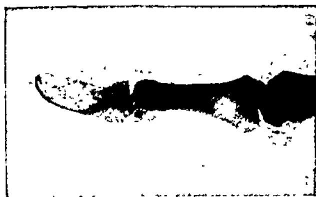


Fig. 413.—Epidermoid cyst causing pressure atrophy of the bone. Lateral view of the cyst shown in the preceding figure. (Compare with figure 397.)

Straus[20] reports an interesting case of a branching, lobulated lipoma beneath the deep palmar fascia in a man of 34 years. The growth was spread out so that it filled the space between the flexor tendons of the third and fourth fingers (Fig. 414). The growth was removed with some difficulty under general anesthesia. These deep lipomas of the hand are classified into those which originate in the tendon sheaths (endovaginal) and those which originate outside of the tendon sheath (epivaginal). About 35 cases have been reported.

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[illegible] tenosynovitis.

Complete surgical removal is likely to be quite difficult, especially if the process extends from the volar to the dorsal surface, infiltrates muscle planes, or follows the course of the tendon sheaths." Bartlett[21] reports 2 cases of periosteal lipoma.

Giant cell xanthomatic tumors (giant cell sarcoma, xanthosarcoma) are tumors whose cut surfaces are yellowish and which contain giant cells. The tumor generally does not metastasize or cause death, but it is somewhat prone to local recurrence. These tumors take their origin from bone and tendon sheaths but also may originate from subcutaneous tissue or other fibrous tissue. The writer has seen one which apparently arose from the aponeurosis of the forearm.[22] They grow slowly over several years, but trauma may cause a more rapid growth. Occurring as isolated growths of the fingers and hands, they are considered to be benign.[23] They are more common in adult life, in females and on the right arm or hand. They are more common on the flexor surface; in order of decreasing frequency they occur on the index finger, the thumb, the middle finger, the little finger, the palm, the ring finger and the wrist. Save for rare instances of pain or tingling along the finger, they are symptomless.

Tumors of Tendons and Tendon Sheaths.—Dean Lewis[24] says: "Among neoplasms of the tendon, benign osteochondromata, ganglions, and giant-cell tumors or xanthomata predominate. These tumors show a relationship to precartilaginous tissue. Fibromata and lipomata also may occur. Tumors of the tendon proper and sarcoma are rare. Chondro-



Fig. 414 —Lipoma of the hand. (Straus, F. H.: Ann. Surg. 94: 269, 1931.)

sarcoma at or near the insertion of tendon into bone, and fibrosarcoma of the tendon sheath are two rare forms of malignancy found in these structures." Giant cell tumors of the tendon sheaths, erroneously classed as xanthomas, are in reality tumors of the sesamoid bones. (Lewis and Geschickter.[25])

As a result of study of the literature and of the records of 70 patients treated at the Mayo Clinic since 1919, Galloway and his associates[26] have been able to conclude that "xanthoma of the tendon sheaths and synovial membranes is a benign lesion associated primarily with an alteration in the [illegible] [illegible], infection or both." They say: "This tum[illegible] [illegible] ch is harder; lipoma, which is softer; carci[illegible] [illegible] which is harder and connected with the b[illegible] [illegible] ensor surface, near a joint and softer." Local excision only is advised.

Morton[27] concludes: "Tumors of the tendon sheaths are closely related to tumors of [illegible]

(3) chondrosarcoma. Harkins[29] has collected reports of 24 cases of hemangioma of the tendon or tendon sheath.

Ragins,[30] in reporting several benign tumors of the tendon sheaths of unusual size, says that these tumors are true neoplasms; that "cholesterin deposits are secondary to the tumor growths and are liberated by the degeneration of the red blood corpuscles" and that "giant cells are endothelial in origin, and attempt early organization of the hematoma formed by the hemorrhage into the tumor substance."

Giant cell tumors of the tendon sheaths have been reported by Eisen[31] and also by Kurtz.[32] Gonzalez-Aguilar[33] regards "the giant cell tumors of the tendons and tendon sheaths as true blastomatous formations of well differentiated elements of osteoperiosteal and histocytitary origin. The said differentiation sometimes allows the formation of an osteoid tissue, or at least of quite dense connective tissue. Local cholesterosis is a function of the reticulo-endothelial system which enters into the formation of the tumor. Hypercholesterinemia which is an essential factor in the origin of the xanthoma is without importance in the tumor of giant cells."[33] Ragins and Shively[34] say that xanthoma cells are formed only in the presence of iron and cholesterol deposits, which in turn are liberated by the degeneration of the red blood cells. Brenckmann and Jung[35] report a case of chondromas of the sheaths of the flexor tendons of the hand. King[36] has reported 7 cases of malignant tumor of the tendon sheath. (See Synovioma.)[37]

Synovioma.—Synoviomas are malignant tumors which originate from the synovial membrane and are found in or about joints. Moretz,[38] who reports 4 cases, prefers the term "malignant synovioma." Fehr[39] believes the tumor to be sarcomatous in nature. It has a slow growth. Coley and Pierson[40] say: "In early cases pain may be the only complaint. This is described as being dull, aching in character, and is particularly aggravated by weight-bearing. One author suggests that this is evidence of invasion of the periosteum, but it should be borne in mind that the synovial lining of joints is very sensitive, and when these structures are inflamed or compressed, severe pain results. Joint function is often surprisingly unimpaired and bone is not usually involved, so that radiographic examination may be entirely negative. Wagner,[41] however, has called attention to the fact that if films are made for soft tissue detail, the presence of the tumor may be revealed, and this was demonstrated in one of our cases. Knox states that in some cases joint tuberculosis may be sim- [illegible]

location of the tumor may make it difficult to remove as much pathologic tissue as desirable. Once the tumor has recurred, it is not likely to yield to further conservative operation, and resort to a radical procedure such as amputation, is necessary." These tumors are resistant to irradiation.[42]

Hemangioma.—Speed[43] reports 3 cases of hemangioma of the hand and recommends radical excision with postoperative splinting.

Trigger Finger (Snapping Finger).—A careful anatomic study of 14 cases of this interesting condition has been made by Kroh.[44] According to him, the disturbance of motility is often erroneously believed to be in the interphalangeal joint, whereas it often occurs at the level of the metacarpophalangeal joint at the point where the tendon sheath is narrowed by the accessory volar ligament. While the disease is more common in adults, it may occur in young children. Jahss[45] reported on 10 patients ranging in age from 3½ months to 15 years, all of whom underwent operation. Harrenstein[46] reports on 12 children, 8 of whom were cured by conservative measures.

The trigger phenomenon may occur with flexion or extension or both of these movements. The inhibition of the tendon movement may arise as the result of localized thickening of the tendon with greater or less narrowing of the tendon sheath due to thickening or chronic inflammation. In the latter condition the disturbance of motility may be due to pain, and the phenomenon of slipping or jerking may be absent. Harrenstein[46] obtained cures in most of

his cases in children by rest and fixation by splint. I have observed a case of snapping finger of such severity that extension could be accomplished only by forcible use of the other hand. Recovery resulted after simple splinting in extension for about ten days.

For children, Jahss says: "There is only one treatment and that is surgical. It consists of dividing the thickened and constricted sheath longitudinally until the fusiform swelling of the tendon moves freely on passive motion. In closing the wound, only the skin is sutured. The child is encouraged to move the thumb immediately. The thickened sheath usually cuts like gristle." In some of the cases the center of the bulbous swelling in the tendon may require excision to restore the tendon to normal size.

Microscopic examination of the extirpated specimen shows hyperplasia of all the elements of the tendon sheath. In a more advanced stage there may be fissuring and vascularization of the fascial tissue of the ligaments, and at an even later stage hyaline degeneration.

In none of Kroh's cases was it possible to obtain a definite history of trauma or chronic inflammation of the joints, in spite of the fact that the processes found in the tendon sheath suggested these factors. In every case the Wassermann reaction was negative. Instead of containing fluid, the tendon sheath was rather dry. In the cases in which the trigger phenomenon was noted, the author found at the level of the proximal accessory band (the accessory volar ligament) a decrease in the caliber of the tendon sheaths and peripheral to this a thickening of one or both flexor tendons. Ottendorf[47] recommends the following treatment of such cases of snapping thumbs as were due to thickening of the tendon sheaths. Under local anesthesia a tiny narrow-bladed knife was introduced subcutaneously into the tendon sheath, and the constricted or tight part of the sheath was divided in a longitudinal direction; the result of the operation could be controlled by active flexion and extension of the thumb by the patient; the operation ought not to be considered complete until the tendon moves without obstruction. Following the operation, early and frequently repeated movements of the tendon were necessary to prevent the formation of adhesions. Hudson[48] has seen 8 patients with a snapping thumb within two years, all occurring at the age of 3 years or earlier. Compere[49] reports a case of bilateral snapping thumb due to involvement of the flexor pollicis longus tendons and describes the surgical treatment.

Stenosing Tendovaginitis at the Radial Styloid (De Quervain's Disease).—First described by De Quervain,[50] this disease is characterized by pain localized over the distal end of the radius (radial styloid) and pain caused by motion of the thumb. The common sheath of the extensor pollicis brevis and the abductor longus tendon is thickened and sensitive. Zadek[51] says that in infants "the striking feature of this condition is its manifestation in a flexion deformity of the interphalangeal joint of the thumb. Unless one is familiar with the condition, it may be considered a dislocation at the interphalangeal joint." (Fig. 415) Potter[52] considers the diagnostic sign of Finkelstein[53] to be excellent. "The patient's thumb is placed in the hollow of the palm and grasped by the remaining fingers. With the hand in this position even slight forced ulnar deviation at the wrist will produce excruciating pain." According to Potter the "treatment consists in longitudinal division of that portion of the dorsal carpal ligament which overlies the sheath." Zadek[51] splits the narrowed sheath. In some cases it may be wise to excise portions of the ligament or the sheath or both.

Calcareous Tendinitis.—In this condition the roentgenogram shows a calcified deposit near a painful joint. According to Cooper[54] the treatment is immobilization in plaster of paris. Vasko[55] reports a case of calcareous tendinitis of the flexor tendon of the finger. The condition responded to conservative treatment.

Exostosis.—An exostosis is a benign bony growth which projects from the surface of the bone. It is extremely rare in the hand.[19] *Subungual exostosis*

rarely occurs in the hand. Mason says: "The subungual exostosis occurs as a chronic, slowly growing, painful tumor which tends to push up the nail, and may give rise to a chronic granular purulent mass. Treatment consists of removal with the least possible damage to the nail bed." Exostoses occur



Fig. 415.—Flexion deformity in stenosing tendovaginitis. (Zadek, I.: J. Bone & Joint Surg. 24: 326, 1942.)

most commonly in males, the average age being in the third decade. Meyerding[56] believes that heredity and metabolic disturbances in childhood are most important etiologic factors and that trauma is of less importance than the histories suggest. In 265 cases at the Mayo Clinic, Meyerding found 65 in the femur, 34 in the tibia, 30 in the humerus and 26 in the foot. The symp-



Fig. 416 —Enchondroma of the metacarpal (Surgical Dispensary, Northwestern University Medical School Courtesy of Dr. John A Wolfer)

toms are a hard swelling formation. Meyerding places stress upon the importance of x-ray study in the diagnosis.

According to the roentgenographic findings of exostosis, the cortical point of origin is in the diaphysis near the epiphysial line, most commonly in the lower end of the femur and the upper end of the tibia and humerus. The base

of the tumor varies from a narrow to a broad pedicle, and the tumor ranges from a bony projection to a pedunculated mass of varying size. The cortex of the bone and the pedicle of the tumor may appear to be continuous. A cartilaginous cap is common; frequently this has a cauliflower-like appearance. An inflamed bursa may produce a distended sac. The tumor may be



Fig 417.—Roentgenogram of the tumor shown in the preceding figure, an enchondroma of the thumb. (Surgical Dispensary, Northwestern University Medical School. Courtesy of Dr. John A. Wolfer.)

local or general. There is penetration rather than invasion of tissue. No absorption of bone occurs unless there is pressure on neighboring structures. The periosteum is expanded over the tumor, which usually occurs away from the joints.



Fig. 418. Fig. 419.

Figs 418 and 419.—Calcification of the terminal phalanx of the finger of a seamstress following repeated needle wounds. (Courtesy of Dr. John L. Porter.)

The treatment of these tumors is surgical when their presence causes deformity or pain. Cauterization of the base and the use of a rubber tissue drain is advisable. In cases of single tumors the prognosis is good.

In 89 cases of bone lesions of the hand and foot treated at the Johns Hopkins Hospital, Kahn and Cohn[57] found the pathologic diagnosis to be exostosis in 28, chondroma in 11, giant cell tumor in 8, myxoma in 6, osteitis fibrosa in 4, sarcoma in 2, osteomyelitis in 2, epithelium-lined cyst in 2, hemangioma in 1 and ossifying hematoma in 1. The diag-

nosis of the largest group, the exostoses or osteomas, is rarely difficult. From the standpoint of treatment it is especially important that myxoma be recognized by the surgeon, as the use of the cautery offers practically the only chance for the cure of this tumor (Kahn and Cohn).

Chondroma (Osteochondroma, Enchondroma).—Mason[58] says: "The chondroma is the only bone tumor which occurs with any frequency on the hand and, *curiously enough, the* hand is by far its most frequent location. It occurs most often as an isolated tumor located in the shaft of a metacarpal or phalanx and has never been recorded in a carpal bone. Although it occurs at any age, it is most often seen in patients under thirty years—a fact which suggests a congenital origin.

"The tumor is confined to the shaft of the bone and although the cortex is markedly expanded over a half to two-thirds of its circumference, the tumor rarely breaks through and invades the soft parts. Fracture of the bone through the tumor area is frequent, but even then soft-tissue invasion does not occur. On cutting down on the tumor, the nerves and tendons will be found to be uninvolved, though often pushed aside or stretched and flattened over it. The tumor itself is a pearly translucent gray, or a light yellow gelatinous or gummous mass, poorly vascularized and easily separated from the surrounding bone



Fig. 420.—*a*, Chondroma of the finger; *b*, roentgenographic appearance. (Kurtzahn, H.: Kleine Chirurgie, Berlin, Urban & Schwarzenberg, 1929.)

with a curette. Except for the presence of a hard, slowly growing, or stationary tumor, few symptoms are present. In fact, the occurrence of a pathologic fracture may be the first evidence.

"The roentgen findings are fairly definite and help to differentiate it from the only bone tumor with which it might be confused—the giant cell tumor. The latter is seen practically only in the metacarpals, and there quite rarely, and in *x*-ray is somewhat more definitely trabeculated and vesicular than the chondroma. Bone cysts, sarcoma, metastatic carcinoma, and myeloma are infrequent and have rather typical roentgen findings. The tumor is essen*tially benign*, but may recur after incomplete removal. It does not have the tendency to sarcomatous degeneration, evidenced by chondromas situated nearer the trunk.

"Treatment consists of complete removal, usually with a curette and chemical cauterization of the cavity with Zenker's solution or 50 per cent zinc chloride. Usually some portion of the shaft of the bone will be found strong and intact, and this will preserve continuity. When the entire shaft is so thinned that it cannot be preserved, an autogenous bone graft may be used, or some other method used to replace the bone. Only if repair is impossible should a finger be amputated for chondroma.

"Occasionally the chondroma does not lie within the bone, but is found attached to the periosteum and may invade the cortex. McWhorter has reported an interesting case of this kind in which the proximal phalanx and metacarpal of the right thumb were entirely surrounded by a cartilaginous tumor separated by periosteum from the bone, except in one spot."

Giant Cell Tumor.—In a giant cell tumor the *x*-ray has a "soap-bubble" appearance due to the many trabeculae running through the tumor. Its treatment is the same as that of chondroma.[59]

In 1931 Geschickter[60] made an exhaustive study of 500 fibrocartilaginous tumors of bone and reached the following conclusions:

"The gradations in a single type of tissue differentiations met with in the osteochondromas (in which bone predominates), in the benign chondroma (in which cartilage predominates) and in the primary and secondary forms of chondromyxosarcoma (in which myxoma and fetal cartilage predominate) seem to imply a close relationship between the formation of tumors and the factors concerned in the growth and differentiation of tissue.

"Apparently all of these various tumors have their origin in a single mother substance, an early precartilaginous connective tissue, and their varying degrees of malignancy are an expression of the rate and extent of differentiation of this tissue. When the rate of differentiation is slow and the extent of cartilage and bone formation is large, a benign exostosis results. When the rate of differentiation is rapid and the amount of adult cartilage and ossification is small, the neoplasms take the form of a chondromyxosarcoma. When an intermediate condition prevails, a benign chondroma, showing a definite tendency to malignant change in many instances, is produced.

"In all these tumors, however, the [illegible] nancy is predetermined in the tissue at the time of the tumor's origin or whether it is dependent on the etiologic factor precipitating the growth, is difficult to decide. Apparently, however, the etiologic factor is a secondary and variable influence."

Platt[61] studied the clinical and roentgenologic pictures of 20 *cysts of the long bones of the hand and foot.* He found that the bones involved, in order of frequency, are the phalanges (of the hands), metacarpals and, more rarely, the metatarsals. The cysts originate in the growing ends (metaphysis). The favorite digit is the little finger. The majority of cysts develop insidiously, remain latent for a time and are discovered after the occurrence of local injury. Spontaneous fracture is a fairly common phenomenon. In 13 cases in which a microscopic examination was made of material removed at operation, two varieties of lesion were distinguished: chondroma (myxochondroma) and osteitis fibrosa. The most effective method of eradicating the lesion is to curet the contents and cauterize the interior of the cyst with pure phenol (carbolic acid). This procedure is best combined with the insertion of one or more autogenous bone grafts, which hasten the obliteration of the cystic area. Struempel[62] says the danger of malignant degeneration increases with age.

Glomus Tumor.—This is a benign tumor involving the neuromyoarterial glomus and was originally described by Masson,[63] in 1924. The neuromyoarterial glomus is an "arteriovenous anastomosis fairly well supplied with nerve fibers and found scattered in the skin especially of the extremities. It appears to have something to do with local circulation and heat regulation." (M. L. Mason) In the words of Raisman and Mayer:[64] "It is small, usually not more than ½ inch (1.27 cm.) in diameter, of slow growth and long duration. It may be situated in any part of the body, but the favorite site is beneath the nail. There it gives rise to pain of varying intensity and radiation. In the severe cases the pain is agonizing, almost paroxysmal, and radiates upward to the shoulder, even to the heart. When the tumor is not subungual, the pain is usually much less severe. Changes of temperature, particularly cold, increase the severity of the pain. Invariably, the tumor is sensitive to pressure.

In some cases it is associated with neurologic or vascular changes such as hyperesthesia and increase in the temperature of the skin. . . . Examination reveals a pea-sized tender tumor, which, when subungual, has almost always a peculiar bluish tinge showing through the translucent nail. The *x*-ray picture of the growth in this situation may show a minute crater-like depression of the dorsal cortex of the terminal phalanx." The tumor is solid and is rose to purple in color. It may occur at all ages but generally is noted in later life. In 8 of the 10 cases reviewed by Adair[65] the average duration was nine years. Four glomus tumors in the same family have been reported by Kaufman and Clark.[66] Milch[67] observed that subungual glomus tumors may cause pressure atrophy on the dorsal surface of the terminal phalanx. Beaton and Davis[68] analyzed 271 recorded cases of glomus tumor. The distribution in 112 cases in men and 111 cases in women is shown in figure 421.

The microscopic appearance is described by Adair[65] as follows: "Under low power the lesion appears to be irregular, tortuous, cavernous blood vessels except that the walls are peculiar The lining endothelial cells are cuboidal and rest on a thin collagenous membrane. Some of the vessels are surrounded by a layer of circular muscle, passing gradually into a zone of 'epithelioid' cells. These cells are globular and their nuclei are spheroidal."

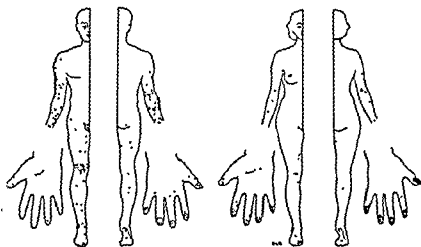


Fig. 421.—Distribution of single glomus tumors in the male and female; composites of 112 reported tumors in men, 111 in women. Each dot represents one nodule. Laterality has not been taken into account. (Beaton, L. E., and Davis, L.: Quart. Bull. Northwestern Univ. M. School 15: 245, 1941)

Raisman and Mayer[64] say: "Glomal tumor is easily differentiated from most of the cutaneous neoplasms. Only two of the latter may cause difficulty. First, the unusual single small neuroma, superficially located; second, the subungual melanoblastoma. This very malignant tumor at one phase of its development is characterized by a bluish-black spot beneath the nail which might be mistaken for a glomus. Operation and microscopic section will at once make the differential diagnosis possible."

Love[69] says: "Usually the patient gives a history of severe paroxysms of pain which seem to originate at the site which subsequently is proved to be the site of the lesion If it is in the finger, he speaks of the neuralgia like pain which starts in the finger and extends therefrom. The pain may involve half of the body. Sometimes hemiparesis or hemianesthesia may occur on the side of the lesion. In one case reported in the literature Horner's syndrome was present on the side of the pain. The lesions are sometimes extremely small and, therefore, if the typical purplish color is absent, they may not be seen. If the typical purplish discoloration can be seen, particularly under the fingernail, then the tumor usually is easily recognized. A complication which may arise from this tumor is hemorrhage. If it is eroded, severe hemorrhage may occur because of the nature of the glomus, for an

arteriovenous anastomosis occurs in the glomus. The question of whether or not malignancy may occur in these lesions is debatable. Within the last few years one or two cases which appeared to be authentic have been reported in which malignant lesions have occurred, but generally glomus tumors are considered benign.

"The pin test to which I referred in the diagnosis of the lesion is employed as follows. An ordinary steel pin is used. The patient is asked to indicate the point of maximal pain or tenderness. Oftentimes as the physician passes his finger toward the spot of the maximal pain, the patient will withdraw his extremity just as the patient with trigeminal neuralgia will withdraw his face when the trigger zones are approached. However, when the patient's confidence is gained and the point of a steel pin is used to examine around the lesion, the point of the pin can be pressed into the skin as near as 1 cm. to the lesion without producing severe pain, but just as soon as the point is pressed over the lesion, the patient will have an excruciating attack of the characteristic pain projecting from the lesion. On many occasions when I could not see the lesion, I have been able to identify its location and make the diagnosis with the help of the pin."

Love adds: "Contrary to the experience of others, my experience leads me to believe that immediate relief of pain does not occur after complete removal of the lesion. Whether



Fig. 422.—Typical subungual glomus tumor beneath the nail of the little finger (infra-red photograph). (Love, J. G.: Proc. Staff Meet, Mayo Clin. 19: 113, 1944.)

this is due to the fact that the pain pathway to consciousness has been so engraved that some time has to elapse before complete relief of pain occurs, I am not prepared to say, but I have made it a practice recently to warn the patient before operation that he cannot expect immediate relief following operation. Since complete relief does ensue, it is rather difficult to explain it on any other basis. The lesion when completely removed, of course, will not recur."

The only effective treatment of glomus tumor is excision. When subungual, a portion of the nail will be removed. Local anesthesia is advisable. Complete recovery is the rule after excision.

Solitary Leiomyoma of the Skin.—Of these tumors Stout[70] says: "The cutaneous and subcutaneous leiomyoma is a small tumor varying usually from the size of a pea to that of a walnut and only occasionally growing larger, the maximum being the size of a child's head. The tumor occurs with equal frequency in both sexes and may appear at any age, although more than half have developed after the twenty-ninth year. It is rounded and occasionally pedunculated. Unless fixed in the skin, it is freely movable. The overlying

skin is colorless or has a reddish or bluish tint. The tumors are found especially on the extensor surfaces of the extremities, more particularly the lower, and in the scrotum, labia majora, nipple, areola, and cheeks. Less frequently they occur in other parts of the body. They are of slow growth and long duration. Usually they are painless at first but sooner or later many of them become painful and tender, the pain being of paroxysmal character and

is derived from one or another of the smooth muscle structures of the skin and subcutaneous tissues. Histologically the leiomyomas can be divided into two groups: the nonvascular and the angiomatous. The vast majority are benign and are cured by excision. Seven malignant leiomyomas involving skin or subcutaneous tissues have been recorded."

Painful Subcutaneous Tubercle (Tuberculum Dolorosum).—Stout[71] says that an investigation of 2,081 superficial tumors of the skin and subcutaneous tissues showed that 20, or approximately 1 per cent, were associated with attacks of paroxysmal pain. The tumor types included not only leiomyoma and glomus tumor but also neurofibroma, fibroma, fibrosarcoma, keloid, dermoid cyst and benign epithelioma in a sebaceous cyst. The tuberculum dolorosum, therefore, is not confined to a single tumor form but may manifest itself in a variety of morphologic types. No adequate explanation for the occurrence of the attacks of paroxysmal pain could be found.

CONGENITAL AND ACQUIRED DEFORMITIES OF THE UPPER EXTREMITY

Polydactylism (supernumerary digits) occasionally is found in infants at birth. There is a marked hereditary element, and both fingers and toes may be involved. The classification of Annandale[72] is satisfactory: (1) a rudimentary digit loosely attached to any part of the hand or foot or to another digit; (2) a more or less developed digit, articulating with the head or side of a metacarpal, metatarsal or phalangeal bone; (3) a perfect digit, with metacarpal or metatarsal bone of its own; (4) a digit united in its length to another articulating with a metacarpal or metatarsal bone of its own, or with one shared with another digit. An extremely interesting case is reported by Penhallow[73] in which there was complete absence of the thumb on each hand, each being replaced by two complete and functioning digits. Because of the unsightly appearance in most cases, amputation is indicated. The proper time to perform such an amputation is in the early weeks of the child's life, preferably in the first three weeks. *x*-Ray examination invariably should be made in order accurately to identify which of the phalanges are superlative or to determine whether there is an exostosis at the side of any of the phalanges. The supernumerary digits may readily be amputated with the patient under general anesthesia induced with a few drops of ether. The extra phalanges should be disarticulated and the skin closed with two or three interrupted horsehair or dermal sutures. In the case of a supernumerary thumb it is not uncommon to find that the supernumerary thumb and the thumb proper are of about equal size and diverge from a common stalk in the manner of a Y. The smaller thumb always will be removed. After its removal the parents always will be troubled by the lateral deflection of the remaining digit. The correction of this deflection by splinting is generally not very successful. It is usually adequately taken care of by the growth of the child and by the continued use of the digit. A straight digit may be promised with reasonable surety. In adults or in cases in which the strength of the hand might be jeopardized, operation may be contraindicated. Cooperman[74] reported a rare malformation of the hand caused by "fusion of a supernumerary metacarpal to the lateral ulnar margin of the fifth metacarpal." This

unsightly deformity interfered with the normal use of the hand. A favorable result followed operation.

Syndactylism or Web Fingers.—Congenital webbing of the fingers is a relatively common anomaly. The web may involve the spaces between any of the fingers or between the index finger and the thumb and may be of varying length, in some cases extending even to the finger tips. Lovett[75] classifies syndactylism into four groups: (1) The union may consist of a thin membrane. (2) The uniting structures may consist of skin which may exist merely as an extension of the normal one. (3) The connection between the two fingers may be a firm structure of skin and fascia fusing the two fingers into one, with perhaps only a single nail for the two. (4) Finally the union may be osseous, generally affecting the terminal phalanges but also at times causing fusion of all the bones of the two fingers. Before operation to correct this condition is undertaken *x*-ray examination should be made. A variety of surgical procedures has been suggested and employed for the correction of the deformity.

"Agnew's operation, in which a dorsal flap is made and used to form the apex of the cleft, is very satisfactory in preventing refusion at the proximal portion of the web. By combining this procedure with skin grafting and the forming of small longitudinal flaps on one of the fingers, the results have been pleasing in obtaining a normal appearing and functionally good hand."[76]

A common procedure is the Didot operation. By this operation one web at a time is corrected. When the little and ring fingers are involved, a longitudinal incision will be made upon the volar surface of the ring finger and the dorsal surface of the little finger. The flaps will be then separated back and rearranged so that the volar flap is turned up on the dorsum of the little finger and the dorsal flap is curved under the volar surface of the ring finger. The flaps are secured in position by interrupted horsehair or dermal sutures. A dry dressing is applied. The operation is not advised, as it rarely produces a satisfactory result. In suitable cases a simple method is that advocated by Woolsey.[77] This author, with the use of a local anesthetic, applies a crushing clamp to the web, and bandages and splints it in place for a period of from eight to fourteen days.

Davis and German[78] summarize in part their extensive study of syndactylism as follows:

"In congenital cases, we have found that we can eliminate considerable deformity by the early separation of completely fused fingers of unequal length far enough back to allow unhindered individual digital growth; this is difficult to correct subsequently. The separation should be made as soon as the inequality of growth becomes apparent, however young the child may be, and skin should be grafted over the raw surfaces.

"We have also found it advisable not to separate the fingers completely and reconstruct the new commissure until the child is at least six years old, as the work will have to be repeated in the majority of cases if it is done too early.

"The key to final success in both the congenital and the acquired types of deformity is the [illegible] ished by the [illegible] the fingers, if it is sufficiently lax to be closed without undue tension, otherwise a graft of whole thickness skin should be used. We feel that the use of whole thickness grafts for covering the raw surfaces and also for forming the commissure, is the method of choice in many instances, as by this procedure the problem of complicated flaps and undue tension can be avoided."

Congenital Hypertrophy of the Finger (Macrodactylia).—No treatment is required for this rare condition except in those cases in which the finger is so large as to interfere with the function of the hand. In this case the entire finger or the distal two phalanges may be amputated under local anesthesia. Rogers[79] reports a symptomless congenital enlargement (macrodactylia) in the right thumb and index finger of an 8 year old girl. Elongated irregular tumors were surgically removed from volar surfaces of the involved fingers. Microscopic examination of the tumor showed them to be neurofibromas with an unusual amount of adipose and connective tissue.

[illegible] his associates[80] report 6 cases of this interesting [illegible]

[illegible] Fingers.—In this unusual condition one or more of the fingers may be completely absent. Hanflig[81] reported a case of congenital asymmetric shortening of the metacarpals which was associated with marked bilateral metatarsus atavicus.

Congenital Dystrophies of the Nails.—This interesting condition is very unusual. Jacobsen[82] reported a case of congenital dystrophy of the nails of the hands and feet. The condition is hereditary. Of 64 members of five generations, Jacobsen found 22 to be affected. This author believes thyroid therapy worthy of a trial. In Thompson's case[83] the brittle [illegible] chylic chloranemia.[85] *Leukonychia striata transversa arsenicalis* is the condition characterized by diagonal white stripes on the nails in arsenic poisoning.[86]

Split Finger Nails.—Carter[87] has suggested a treatment of the sometimes distressing condition of split finger nail. Primarily attention is given to building up the general health. The nail was permitted to grow ⅛ inch beyond the finger. Three holes were then drilled in each side of the split in the nail and the nail edges firmly approximated with fine strong

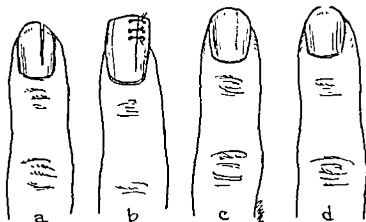


Fig. 423.—Treatment of a split finger nail. *a*, Original condition. *b*, Sutures placed through holes in the nail. *c*, Nail in process of healing *d*, Completed cure. (Carter, W. W.: J. A. M. A. 90· 1619, 1928)

suture. As the nail grew, its distal end was pared off, and other sutures were placed near the end of the finger. This process was continued until a cure was effected in six weeks (Fig 423). If the nail is too short for this treatment, Webb[88] applies "scotch tape" to protect the nail.

Congenital Contracture of the Palm.—Jorge[89] reports a case of congenital contracture of the hand in a 3 year old girl whose mother had a similar contracture which had been present since her birth. The Wassermann reaction was positive for both mother and daughter.

Madelung's Deformity.—In this condition there is an abnormal curvature of the radius, with more or less marked dorsal luxation of the lower end of the ulna. Anton, Reitz and Spiegel,[90] in reporting a case, have made a very thorough study of the subject and have analyzed 171 reported cases. They suggest the term "*dyschondroplasia of the distal radial epiphysis*" instead of Madelung's deformity. This disease usually develops between the ages of 12 and 16 years and is rare in early childhood. It is four times more common in females than in males. It is generally bilateral and more marked on the right than on the left. Madelung[91] thought the immediate causes of the deformity to be found in a retarded growth of the joint. Catterina[92] concludes that the cause is a late form of rickets developing in adolescence and that the

deformity is increased by forced dorsal flexion of the hand in the patient's work, this accounting for its being more marked on the right side. This author says that, as a rule, the condition is painless, while Lovett[93] says that pain is a common symptom. The latter adds that the function of the hand is most disturbed in the direction of rotation and hyperextension, which is painful, while flexion may be increased. Orthopedic treatment gives good results if it is begun in the early stages. Surgical treatment should be given only in very severe cases and should consist in an oblique linear osteotomy of the lower third of the radius (Catterina).[94]

Cicatricial contractions following burns by heat or strong chemicals may be so marked as to interfere with the functions of the hand. When involvement is of lesser degree, no treatment will be necessary, the use of the hand and the elasticity of the adjacent skin will overcome the defect of function. In the more marked cases the excision of the scar tissue and the substitution of a full thickness pedicle flap or tubular graft is a difficult surgical procedure which does not belong to the realm of minor surgery.[95]

Dupuytren's Contracture.—In this condition there is permanent flexion of one or more fingers, due to contraction and hypertrophy of the palmar fascia and its digital prolongations. The ring finger is most frequently involved, with the little finger, middle finger, forefinger and the thumb following in order of frequency. It was first described by Dupuytren, in 1832. The cause is not definitely known, but three factors appear to have some significance.[96] These are heredity, senility and a fibroplastic diathesis or predisposition. "The essential process in Dupuytren's contracture is benign fibroplasia of the palmar connective tissues."[92] Meyerding and his associates[97] have studied microscopic sections of the palmar fascia in 57 cases of Dupuytren's contracture and conclude that "the pathological picture is best explained on the basis of a chronic inflammatory process." Clay[98] believes that Dupuytren's contracture is due to a neoplasm—"a cellular fibroma of the palmar fascia." The condition is more common among males. There are few if any subjective symptoms. The objective symptoms begin with a nodule or nodules in the palm of the hand, and a gradually increasing contracture which may take as much as years to develop. Oehlecker,[99] in whose series of 25 patients the youngest was 31 and the oldest 74 years old, says that operation is indicated only in cases of severe contraction. Kanavel, Koch and Mason[100] have operated in 29 cases and have obtained good results in 20 cases. These authors state that they place importance upon the following factors:

"1. Wide excision, not only of the contracted fascia, but of all its attachments to the skin, the interfascial septa, the volar interosseous fascia, the metacarpal bones, and the phalanges. Although in such an operation normal fascia may be removed, they do not consider this a disadvantage, but rather an added guarantee against recurrence.

"2. Careful dissection and elevation of the skin to avoid trauma and subsequent necrosis.

"3. Painstaking effort to avoid injury or subdivision of the digital nerves and blood vessels which are frequently embedded in the bands of fibrous tissue which draw the fingers into flexion.

"4. Excision of skin that is hopelessly involved, and replacement of the excised skin by a free full thickness graft rather than attempting to bring together wound edges under tension.

"5. In long-standing cases, with marked contraction of the fingers, excision of the head of the proximal phalanx, and shortening of the extensor tendon of the affected fingers through a dorsal incision (Hutchinson's operation).

"6. Active movement of the fingers and hand as soon as the operative wound is soundly healed."

Patients may be operated upon under regional local anesthesia, 0.5 per cent procaine without adrenalin being suitable. When the operation is done under local anesthesia, the cooperation of the patient in moving the finger during the operation, thus revealing the time when the fascia is sufficiently removed, is very helpful. (Webb) A transverse incision is made in the cases of lesser involvement, and in the more severe conditions a longitudinal incision adequate to expose the entire fascia will be employed.

Meyerding[101] uses the cuff of a sphygmomanometer in order to obtain a bloodless field. He says:

"I usually expose the narrow, upper end of the palmar fascia, isolate it with small, blunt-pointed dissecting scissors, pass a hemostat under it and, after clamping it firmly, divide it with a knife. The fascia can then be raised by gently pulling the forceps away from the palm, and with a fine knife or scissors the fasciculi can be divided as they pass in various directions. The dissection is continued distally until all contracted fascia has been freed; if such fascia should continue into the fingers, separate incisions and dissections should be made. At the time that the contracted fascia is removed from the fingers, great care must be taken in separating the nerves and blood vessels from the fibrous mass in which they lie."[102]

Gill[103] stresses the importance of eradication of focal infection and operates only when the function of the hand is seriously impaired. Homans[104] suggests the value of roentgen therapy and confirms Gill's opinion as to the inadvisability of operating in early cases.

Volkmann's Contracture (Ischemic Contracture; Ischemic Paralysis) (See the section on Elbow Fractures).—This condition is a manifestation of interference with the venous return of flow of blood. In the first stage (Allison) edema, cyanosis and lowering of surface temperature are present. Pain and altered sensation may be marked. In the second stage "there is progressive fibrosis of the muscles, resulting in a fibrous change in all the tissues, with *progressive loss of motion, with varying degrees of anesthesia, but without* the true reaction of degeneration. The pulse volume is reduced, and the sensory disturbance is irregular in distribution." (Allison) The condition is due to an overengorgement of the muscle bundles with blood. Jopson[105] says that the intrinsic pressure causes local myositis and pressure on the nerves, usually the median and ulnar, and upon the blood vessels. According to Jopson, flaccid paralysis develops, followed by swelling of the muscles. Volkmann's contracture is particularly liable to occur after the application of tight splints or bandages. Bruce[106] reports a Volkmann's contracture limited to the middle finger following a blow on the "front of the mid forearm by a tennis ball."

Meyerding[107] says: "Volkmann's ischemic contracture is most frequently associated with supracondylar fractures treated by acute flexion. In the presence of swelling and hemorrhage, acute flexion tends to impair circulation by increasing pressure in the ante- [illegible] the fracture may be de- [illegible] the soft parts in order to [illegible] welling in the recumbent patient."

It has been known to occur in the absence of constricting dressings. It also may occur in forearm fractures and even with fractures of the clavicle. In no event should constricting bandages or plaster of paris be applied when the swelling is still in progress. For elbow fractures the Lund swathe or similar dressing is much to be preferred. It must be remembered that when the elbow is put up in hyperflexion, this position coupled with increased swelling may bring about such an obstruction to the circulation that the arm will have to be lowered to a right angle or, in extreme cases, incision of the bicipital fascia will be necessary. Hey Groves[108] says that full flexion of the elbow can be just as dangerous as a tight bandage. All patients with recent fractures must be kept under close observation. With the onset of edema, cyanosis, lowering of surface temperature and increase in pain, all dressings should be loosened or removed entirely. At times, incision of the arm through the fascia is indicated to obtain relief from the congestion and help restore normal circulation. (Webb)

In an interesting paper Dean Lewis[109] makes the following statements in regard to ischemic paralysis: Ischemic palsy or Volkmann's ischemic contracture is probably more common than is generally believed. It is primarily a myositis dependent upon acute venous stasis following trauma, most frequently a supracondylar fracture of the humerus. The tough antecubital fascia plays an important role in confining the hematoma and preventing expansion. Although tight bandaging and circular casts have been looked upon as the sole causes of the condition, the statistics of Hildebrand and Denucé show that only about 60 per cent of the patients have been treated with a cast.

In dealing with an injury likely to be followed by ischemic contracture, it is important to be constantly on the lookout for signs of developing venous stasis. Severe spontaneous pain radiating over the forearm, especially if it is associated with tenseness and discoloration in the antecubital fossa, is a danger signal. The muscles are swollen and tense and the fingers rigid, swollen and cyanotic. Motion is finally lost.

After development of the palsy the hand assumes a typical position, usually quite distinct from that seen in combined median and ulnar nerve paralysis. The wrist is extended or slightly flexed, and the metacarpophalangeal joints are flexed. The thumb may be rigidly adducted. Extension of the wrist leads to flexion of the fingers, while extension of the fingers leads to flexion of the wrist.

The condition is more easily prevented than cured. In cases of supracondylar fracture with marked displacement the use of a cast or splint is contraindicated, and reduction in acute flexion should not be attempted. Reduction can always be effected later. Poor reduction with good function is preferable to good reduction with ischemic contracture. When ischemic contracture threatens, operative intervention, consisting in longitudinal incision through the antecubital fascia for relief of the tension, is to be considered. The author reports a case in which the patient was much benefited by this procedure.

Jones[110] says: "Treatment should be immediate; every minute is important. The arm should be released from all restraint likely to cause vascular obstruction; it should also be elevated. The child's future is so jeopardized that an attempt should be made to evacuate the blood clot by an incision on the antero-ulnar side of the forearm, and all blood expressed from the antecubital

space. This prompt action may save the situation; it rests on a sound pathologic foundation, and successful cases have been reported."

Wilson[111] says, "Frank, established ischaemia requires immediate operative intervention." He recommends incision along the inner side of the elbow, with evacuation of the hematoma and exposure and freeing of the vessels.

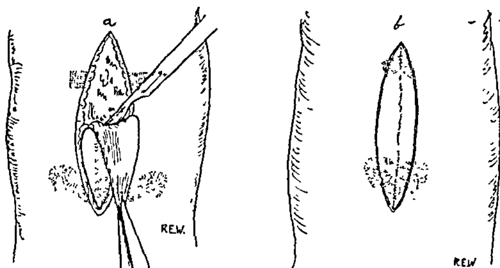


Fig. 424.—Removal of a tattoo mark: *a*, Elliptical excision of part of the tattoo mark; the edges are approximated by suture. *b*, After the wound of the first operation has thoroughly healed, a second elliptical incision is made.

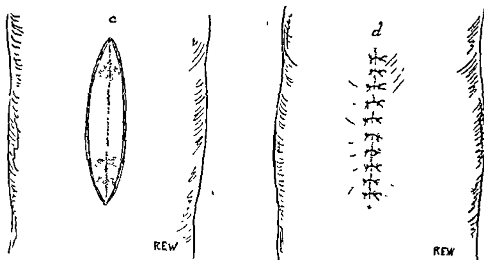


Fig. 425.—After the second incision has firmly healed, if necessary, a third incision is made (*c*) *d*, Wound after removal of the scar.

When the contracture has developed, the prognosis depends on the amount of muscle tissue lost. The results of bone resection, tendon lengthening and myotomy have been unsatisfactory. The best results are obtained by the use of elastic tension and gentle physical therapy, with care to avoid tearing through fibrotic muscle which would lead to further contraction.[107]

Deformities of the Upper Extremity Due to Nerve Injuries.—In case of section of any of the motor nerves of the upper extremity, with paralysis of the muscles which they innervate, the contraction of the opposing muscles will cause flexion or extension, as the case may

be, of individual fingers, the hand or even of the forearm. The paralyzed muscle is subjected to a continuous pull which overstretches it, and the normal opposing muscle, being in a continued state of clonic contraction, is likely to become actually shortened. This danger is prevented by splinting the fingers or hand so as not to permit this overstretching until the nerve has regenerated.

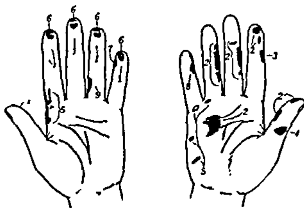


Fig. 426.—1, masons' or bricklayers' worn out left finger tips; 2, jewelers, engravers; 3, barbers; 4, cobblers; 5, golf players; 6, stringed instrument players; 7, French horn players; 8, trumpet, tuba players; 9, trombone players. (Ronchese, F.: J. A. M. A. 128: 925, 1945.)

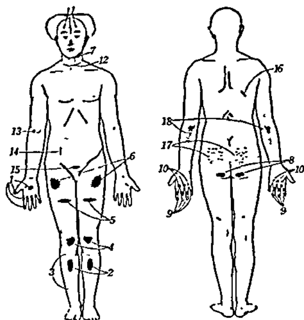


Fig. 427.—1, jewelers, engravers; 2, painters; 3, junk handlers, railroad workers; 4, floor scrapers, plumbers, those who kneel in prayer; 5, packers, bakers, leaning against table; 6, basket carriers; 7, violin, viola players; 8, marks of a sedentary occupation; 9, scrub women, plumbers, knuckle calluses; 10, landscape gardener (metacarpophalangeal knuckle calluses); 11, boxers', wrestlers', ears, nose, eyebrow scars; 12, thyroidectomy scar; 13, blood transfusion scar; 14, [illegible] ark; 16, empyema scar; 17, sca [illegible] workers leaning on the elbow.

Myositis Ossificans. (See the section on Myositis Ossificans.)

Tattoo Marks.—Many proud wearers of tattoo marks lose their pride after a period of years and are extremely anxious for their removal. The tattoo marks themselves are permanent discolorations of the skin. The writer has heard that there are persons who make a specialty of retattooing the offending

marks with a whitish substance which blurs them and makes them unrecognizable. Small tattoo marks may be completely excised. Larger ones, up to 3 or 4 inches in diameter, may sometimes be treated by the process of repeated excision. A central area, perhaps 1 inch across and elliptical in shape, is excised and sutured. Some months later, when union is firm and the normal elasticity of the adjacent skin has been reestablished, this process may be repeated, until eventually all of the tattoo mark has been cut out (Figs. 424–425). Another method is the excision of the tattoo mark and subsequent skin grafting. Electrolysis and various chemicals, such as pheno land carbolic acid, have been used. Blistering of the skin followed by the use of hydrogen peroxide in glycerin or 15 to 20 per cent solution of silver nitrate is also tried. A very interesting study of this subject has been made by Shie.[112] He believes the best method of tattoo removal to be the tannic acid and silver nitrate method of Variot when used with certain modifications. After careful preparation of the skin, 50 per cent solution of tannic acid in water is tattooed into the design. The solution is carried well into the corium. The surrounding skin is protected with sterile petrolatum or collodion ¼ inch from the edges of the design, which is then rubbed vigorously with a stick of silver nitrate.

Wide Scars and Large Disfigurements of the Skin.—The method of gradual partial excision with closure described in the previous section in connection with tattoo marks has been employed by Davis[113] for the removal not only of tattoo marks but for extensive scars, large pigmented moles, pigmented nevi, hemangiomas, lymphangiomas, *x*-ray and radium burns, localized scleroderma, keloids, etc. He finds that better results may be obtained by this method than by any other that he knows of. It should not be attempted for malignant growths. Davis performs the operation with the use of local or general anesthesia. In the first stage, an elliptical piece of tissue is removed, and the edges of the defect are approximated within the growth itself. After healing has taken place another elliptical segment is removed, the edges of the defect being sutured as previously. By this procedure a very wide scar can be converted into a linear scar. As the surrounding skin has time to become stretched between operations, it is possible to remove a large disfigurement which could not be removed at one operation. Undermining of the edges about the excision is contraindicated as it produces more scar tissue.

Calluses, Etc. as Aids in Identification.—Ronchese[114] has emphasized how calluses, cicatrices and other stigmas may serve as an aid to personal identification. Figures 426 and 427 are taken from his article.

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CHAPTER XXI

INJURIES OF THE LOWER EXTREMITY

Contusions, Abrasions, Blisters, and Other Wounds.—The treatment of contusions and abrasions of the lower extremity is identical with that described previously. Clark[1] reports an interesting case of contusion of the external popliteal nerve incurred during an automobile injury. There were marked motor, sensory and vascular changes which improved only after neurolysis of the external popliteal nerve nine months after the accident.

The heel is a particularly common site of blister formation from the traumatism of a too tight or ill fitting shoe. When the friction of the shoe is noticeable and occurrence of a blister seems likely to take place, very useful prophylactic measures consist of the liberal use of talcum powder both inside the sock and inside the shoe, and also the placing of a broad strip of adhesive plaster directly on the skin. Should the blister actually develop it is best protected by removing all friction and pressure, by cleansing with soap and water and washing with alcohol, and by covering it with a small dressing held firmly in place by adhesive plaster. The dressing may be cut in the form of a ring to protect the irritated area. This protection should be maintained until the upper layer of the blister has become dry and has scaled off. Should the blister be very large, it may be aspirated through the intact skin at its border in the manner previously described. If there is evidence of infection within the blister or of actual pus, the roof of the blister should be excised and its floor painted with a 1 per cent gentian violet or Aldrich triple dye and a plain white or borated vaselin dressing applied. If the blister is accidentally torn open by the patient but still appears to be uninfected, the application of a mild antiseptic and a sterile dry or vaselin dressing will generally take care of the condition until the wound has healed. If, however, infection is present, the roof of the blister should be cut away and the floor treated as described previously.

A neglected blister on the heel may have very serious consequences. The author had [illegible]

[illegible] and soon a small abcess discharged spontaneously. A long incision was made over the fibula, and a large subperiosteal abcess was opened. Holes drilled into the marrow of the fibula permitted pus to escape from the inside of the bone. A day or two later the mandible became involved. It was swollen and tender, and large quantities of pus escaped from the gingival border beside the loosened teeth. Both sides of the lower jaw were involved. Tender areas developed in the region of the right pectoralis major and at the lateral border of the right scapula. These latter, however, subsided under hot boric acid fomentations. The blood culture was positive for staphylococci. The patient's temperature gradually [illegible]

Nail Puncture [illegible]
ment of nail pu[illegible]
"Foreign bodies [illegible]

mis or just beneath it. I have demonstrated that nails (6 to 20 penny) coated with methylrosaniline (gentian violet) and driven into a cadaver's foot were wiped clean in the proximal ¼ inch of the tract. In doing a superficial débridement in my cases, I noted that particles of sand were just beneath the epidermis, and occasionally rust particles and little pieces of concrete or rubber were found in the same location. The introduction of a drain into a noninfected wound tends to convert it into an infected wound. . . . The foot is a complex anatomic unit, and several layers of fascia slide over one another when the foot is used in walking. Hence, by the time a patient walks from where he suffers the nail puncture wound to the doctor's office or to the hospital, these fascial planes have slid over one another so that one is dealing with a tract that resembles a staircase more than a straight line." Bowen cleansed the foot thoroughly with hot water and soap for from fifteen to thirty minutes;

soaked in tincture of mercresin. The wound was not probed beyond ¼ inch, and this was

given crutches and told not to bear weight on the affected foot for one or two days. They were told to report to the hospital on the day they returned to work, for inspection of the wound. If any sign of increasing inflammation was present, compresses were advised."

quently the hematoma will subside under rest and elevation. Occasionally, however, it may be so large as to cause interference with the circulation because of pressure. In this event,

nts of
blood
course,

must be made under rigid sterile precautions. After the evacuation of the hematoma, a

He
often
na-
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ent on the size of the vessel, the amount of collateral circulation and the size of the hema-

en exquisitely tender.
flexion contractures
may be attributed to
this factor. Pulsation, determined by palpation, is rarely if ever detectable. But a loud

ation may be present. In such cases the appearance of the lesion is almost identical with that of a large abscess. Even the systemic reaction of abscess may be present, with a low grade fever, leukocytosis and an increase in the sedimentation rate of the blood.

"*The course of 'pulsating'* hematomas is variable. They frequently make their initial appearance within twenty-four hours of the injury. In other cases, probably because the

shock of the original trauma has reduced the blood pressure or because the blood escapes slowly through the recent puncture wound, they do not become apparent for several days. Hemorrhage from the original wound is, however, usually severe. Often when some form of dressing other than a good compression bandage is placed over the wound the mass is noted when the dressing is changed after four to seven days. Secondary hemorrhage after ten days is frequent and is often severe. Probably during this time the mass has had the opportunity of eroding its limiting structures by the mechanism of pressure necrosis. Infection may also play a role. On several occasions I have seen patients for whom some unsuspecting physician has incised the mass, believing it to be an abscess. In these instances the hemorrhage has been severe and controllable only by packing or application of a tourniquet. There have followed repeated severe hemorrhages, extensive enough to bleed through almost any pack. The pack has also added infection, which has much complicated the course and made later care exceedingly difficult. The late course and complications include gangrene of the extremity, pressure on surrounding structures, emboli and secondary infection. Gangrene occurs not only because the main vessel is injured but because the collateral channels are compressed by the tumefaction. Venous stasis is often present, but the veins are not engorged, because their arterial filling is slow. When the ischemia appears to be causing gangrene, resection of the pseudoaneurysm and evacuation of the clot will sometimes permit the limb to resume a normal or near normal circulation. Reflex vasospasm may also play a role."

The treatment consists essentially of provisional ligature of the artery proximal to the hematoma, incision of the hematoma, ligation of the proximal artery (identified, if necessary, by momentary release of the provisional ligature), sulfonamide dusting and loose packing.

Childress[4] says: "(1) Subfascial hemorrhage of the dorsum of the foot frequently complicates metatarsal fractures and soft-tissue damage caused by crushing trauma. (2) The cruciate ligament of the foot may act as a constricting band in subfascial swelling. This condition was produced in eight feet of cadavera injected with dye solutions. (3) Immediate [illegible] tment indi- [illegible] transverse [illegible] block. (5) [illegible] of the soft [illegible]

art [illegible] The swelling itself may be pulsating and give rise to an audible bruit. In the case of smaller arteries the swelling is slow of formation, and the pulsation is a late symptom. In the latter cases surgical intervention is not urgent and may be delayed until the collateral circulation has improved—a period of two or three weeks. In wounds of larger arteries, operation may be very urgent to prevent gangrene from disturbance of circulation. In some cases the injury may be so grave as to require amputation because of the destruction of the major blood su[illegible] and emptied of as much blood as p[illegible] wound or injury, and after evacuati[illegible] injury. In the larger vessels the ma[illegible] procedure of vessel anastomosis is to be considered.

Rupture of Varicose Veins.—Varices and varicose veins of the lower extremities are liable to rupture spontaneously (especially in the neighborhood of varicose ulcers) or following trauma which often may be trivial. The resulting hemorrhage may be very severe and, despite the fact that it is very readily controlled, may even be fatal. The writer has seen 1 such case. The common error in the treatment of cases of this type is the improper application of the tourniquet. Here if the tourniquet is placed above the wound and applied tightly enough to obstruct the venous but not the arterial circulation, the bleeding will be more severe than if the tourniquet had not been applied. Simple direct pressure upon the bleeding point will control hemorrhage in all cases. The relief is more prompt if, in addition, the extremity is elevated. The wound is sponged with an antiseptic solution and covered with

a large pad of sterile gauze, which is smoothly and firmly bandaged in place, great care being taken that the turns of the bandage *above* the wound are not too tightly applied. In the absence of sterile gauze, clean towels or handkerchiefs may be pressed on the wound by hand. It is extremely rare to have to open such a wound and ligate the bleeding vessels.

Hemorrhage into Joints (Hemarthrosis).—Hemorrhage into the joints of the lower extremities may occur as a result of wounds of joints, blows in the neighborhood of joints and severe wrenches with tearing of the ligaments. The treatment will be rest and repeated aspirations with strict aseptic precautions. Milne and Bailey[5] stress the point that "a perforating wound of the lower end of the femur if situated within a hand's breadth of the superior surface of the patella may involve the knee joint."

The immobilization of the injured leg in a plaster cast or Thomas splint with elevation may be necessary. (See the section on joint injuries.) The method of knee joint aspiration will be seen in figure 435.

Rupture of Tendons.—The treatment of this condition is identical with that described previously. (See the section on Tendon Injuries.)

Partial *rupture of the quadriceps tendon* is evidenced by pain on attempts to extend the leg, by localized tenderness and occasionally by an actual depression at the site of the injury if the patient is seen immediately. A patient with partial rupture does very well with prolonged immobilization in a plaster cast (four to six weeks) and the use of physiotherapy during the guarded resumption of walking. Coley[6] reports a case of bilateral rupture of the quadriceps tendon in a man of 54 with recovery following operation.

Rupture of the tendon of Achilles is generally treated by operation. Quenu and Stoianovitch[7] state that incomplete rupture of the Achilles tendon has not been found at operation. These authors say that for rapidity and constancy of results the open surgical treatment is far superior to nonoperative measures. According to Brisset,[8] rupture of this tendon, while not common, is far from rare. In 2 patients seen by Brisset the rupture occurred while the patient was "pushing a barrel." In 1 case it occurred at the insertion and in the other in the upper third of the tendon. The latter case was of special interest because the rupture had remained untreated for three months, with the following effects: marked inability to flex the foot, marked reduction of the force of flexion and rapid fatigue which prevented the patient from working. At operation each fragment of the tendon was found drawn to a point, this making end to end suture difficult. An excellent result was obtained by suturing the tendon and maintaining the foot in extreme flexion for several days. The writer has seen at least 1 patient whom he believed had an incomplete rupture of the tendon of Achilles. Conservative treatment gave satisfactory results.[9]

Lonergan[10] points out that tenotomy or forcible rupture of the tendon of Achilles is a rather common orthopedic procedure. Recovery occurs without tendon sutures. It must be said, however, that when tenotomy is done, the two halves of the tendon should be divided at different levels. Hodgen and Frantz[11] say that the majority of surgeons consider subcutaneous tenotomy of the Achilles tendon an unfavorable surgical procedure. They prefer stretching and the application of a plaster cast. Moreover, in severe fractures of the posterior malleolus of the tibia it may be necessary to divide the tendon of Achilles to maintain position of the fragments. It would seem

that conservative treatment of rupture of this tendon should be given some consideration. Subcutaneous *rupture of the tendon of the tibialis anticus* is rare. Two cases are reported by Burman.[12]

Rupture of Muscles.—The general principles of the treatment of this condition are the same as those described for this condition elsewhere. In 1921 Grassheim[13] analyzed over 500 cases of muscle and tendon tears and found that the order of frequency in the different situations was as follows: (1) tears of spinal muscles, (2) tears in calf muscles, (3) tears in quadriceps muscles, (4) tears in adductors of the thigh ("rider's thigh") and (5) tears in the biceps of the arm (here the tendon most frequently ruptures).

In *tennis leg* there is rupture of certain fibers of the plantaris muscle, of the plantaris tendon itself or even of certain muscle fibers of the soleus or gastrocnemius muscle. Jones[14] calls attention to the fact that the muscle belly of the plantaris is only about one-fifth the total length of the muscle and tendon. The belly is subjected to much greater tension than the other calf muscles and ruptures much more easily. (Daseler and Anson[15] found the plantaris muscle to be absent in 6.67 per cent of 750 consecutive lower extremities examined.[16]) The patient sustaining this injury will have been indulging in some violent exercise, such as tennis or running, and will experience a sudden acute pain in the calf of the leg. The muscles have been thought to tear more easily when the person is tired. Very commonly, he will say that he has looked about to see who has thrown a stone at his leg, and the pain and disability may be very great, according to the degree of the rupture. An English surgeon (Wharton P. Hood, quoted by Binnie) found to his astonishment that those patients who disobeyed his instructions to keep the leg strictly immobilized either in a splint or cast and used the extremity as much as they were able to recovered much more rapidly than those patients who followed the conventional treatment in vogue. Those who have been treated by prolonged immobilization are found to have pain and stiffness for a very long time, occasionally many months. This is due to the fact that the immobilization encourages the organization of the effused blood and the laying down of scar tissue and painful adhesions, binding the affected muscles to the adjacent parts. In these cases the patient should be encouraged to walk and use the extremity as soon as possible. Gentle massage, heat and counterirritants may accelerate the recovery. In the more painful cases a few days of rest and external heat are permissible, but the patient is advised to use the leg as soon as possible. When walking is very painful, strapping with adhesive plaster or elastic adhesive tape or the application of a firm woven bandage ("Adaptic," or "Ace") will be helpful.[17]

Gilcreest[18] reports rupture of the vastus internus, rectus femoris, semitendinosus, gastrocnemius (inner head) and plantaris muscles. He says: "Early surgical repair in extensive or complete tear saves much time and gives a much better ultimate result." Rupture of the adductor muscles of the thigh is reported by Crile.[19] Rupture of the inner belly of the gastrocnemius muscle is reported by Hogarth.[20] Recovery followed operative repair. *Herniation of the lower leg muscles* is described by Cozen,[21] who advises use of an elastic bandage in milder cases. In severe cases the hole in the fascia is enlarged by a cruciate incision rather than attempting closure. Goldberg and Comstock[22] say that such herniations may be confused with varices and the repair should be by suture or strip of fascia lata.[23]

Acute Traumatic Synovitis of the Hip Joint.—Overuse and slight trauma of the hip joint, particularly in children, may bring about a condition of traumatic synovitis of the hip joint. In only 4 of Finder's[24] cases was trauma held responsible. Muscular strain, measles, scarlet fever, influenza and tonsillitis were thought to be etiologic agents, and the cause was entirely unknown in some cases. There is no laboratory evidence of infection, and both tuberculin tests and *x*-ray examinations are negative. The patient's mother will notice that the child is limping and will consult a physician to find out what is wrong with the child's foot, ankle or knee. A very common complaint is pain in the knee, and ill advised treatment of the knee is not infrequently carried out. In all cases of pain in the knee the hip should be examined as well as the knee. The child to be examined should be stripped and requested to lie down upon the examining table. In an individual who is suffering from acute synovitis of the hip joint it will be noticed that he lies upon the table generally with the affected thigh drawn up. When asked to straighten the leg upon the table, he does so reluctantly and slowly, if at all. With the patient lying flat upon his back and the surgeon fixing the pelvis by making firm pressure upon the anterior spine of the ilium on the opposite side, a gentle attempt is made to abduct widely the affected thigh. In practically all unaffected hip joints the thigh generally may be easily made to lie flat upon the table at right angles to the body axis. If the hip joint is affected, the protective spasm of the thigh muscle will prevent more than slight abduction, and efforts to increase it will occasion pain.

In ordinary cases this condition will generally respond promptly to mere rest in bed for from one to three weeks. In the more severe cases it will be necessary to apply adhesive traction to the leg with 3 or 4 pounds of weight and to elevate the foot of the bed for countertraction.

factor in localizing a subsequent infective disease of the joint, and (3) That a traumatic arthritis, accompanied by long-standing intra-articular effusion, may result in permanent weakening of the joint from stretching of the ligaments." Fraser advises immobilization of the extremity in a splint and the aspiration of the joint if the effusion or fluid becomes excessive. When the patient has recurring attacks and chronic synovitis develops, counter-

Traumatic Synovitis of the Knee Joint; Effusion into the Knee Joint; "Water on the Knee." (See Sprain of the Knee.)—This subject has been discussed in the section on traumatic synovitis. To recapitulate, it may be said, however, that effusion into the knee joint is a symptom of all types of knee joint injury. It is important to ascertain the underlying injury and to treat it properly rather than to treat the effusion as an entity in itself.

When there has been no gross rupture of ligaments, or no displacement or injury to semilunar cartilages or no injury to the spine of the tibia and when the mechanical structure of the knee joint is grossly undisturbed, the effusion may be treated by itself. Brickner,[28] in referring to the aspiration treatment of the so-called "traumatic synovitis" of the knee, says that "its beneficence and routine usefulness have not found the recognition that the

method deserves, either in practice or in text-book teachings." This applie not only to knees but other joints.

Here rest, early and repeated aspiration and early joint motion, togethe with external heat, diathermy and massage, are of value. In the more sever cases a circular plaster cast will be applied for four to six weeks and followe by physiotherapy.[29]

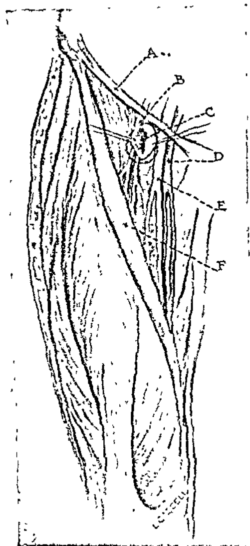


Fig. 428.—Bursa in relation to the important nerves and blood vessels on the fro of the thigh. *A*, Poupart's ligament; *B*, anterior crural nerve; *C*, iliopectineal bursa whi has been opened and broken, the center line indicating the extent of the bursa *itself*; femoral vein; *E*, femoral artery; *F*, sartorius muscle. (Lund, from O'Connor, D. S.: Sur Gynec. & Obst. 57. 674, 1933.)

Bursitis of the Lower Extremity.—*Bursa of the Great Trochanter.*—Th bursa lies between the great trochanter of the femur and the overlying musc When inflamed it causes pain on outward rotation of the thigh. If the bur has become distended, the condition may be accompanied by abducti and eversion of the thigh, and the patient may present somewhat the pictu of hip joint disease, from which condition a differential diagnosis must made. Schein and Lehman[30] report seven cases of acute trochanteric bursi with calcification. They emphasize the favorable prognosis with any form

therapy which induces hyperemia locally. They say that "infiltration with novocain and multiple punctures of the calcific area appear most efficacious."

Ischiogluteal Bursa.—This bursa, which lies between the tuberosity of the ischium and the overlying soft parts, becomes inflamed in individuals whose occupation entails constant sitting. Inflammation of this bursa has been referred to as "weaver's bottom." A distended ischiogluteal bursa, according to McWilliams, may press upon the pudendal nerve and cause referred pain over the distribution of the nerve.

Obturator Bursa.—This bursa lies between the tendon of the obturator muscle and its bony exit from the pelvis. When it is inflamed, the diagnosis may be made by the palpation of the tender exit of the obturator tendon by rectal examination. This condition may simulate coxitis (inflammation of the hip joint).

Iliopectineal Bursa.—Inflammation of this bursa, which lies immediately over the capsule of the hip joint, will cause tenderness in the lateral portion of Scarpa's triangle. When distended it may press upon the femoral nerve and cause pain which radiates down the leg and which appears in the knee, as in cases of hip joint disease. The treatment is rest and heat. Weeks may be required. Repeated aspiration may be helpful and is recommended by O'Connor.[31] Surgical treatment may be necessary.[32] Stephens[33] reports two cases of cystic tumor of the iliopectineal bursa. In one of the cases the cyst communicated with the hip joint.

O'Connor[31] has made a valuable study of iliopectineal bursitis. He says, in part, "The most common symptom complained of in iliopectineal bursitis is pain in the anterior aspect of the hip joint. The pain may be of an indefinite character described best as an aching pain, or it may be a throbbing pain. If the pain radiates, as it frequently does, it radiates to the front of the knee. This radiating pain is a separate thing from the pain of [illegible]

[illegible] and is always located at a point over the front of the upper thigh or inguinal region. This point is just below Poupart's ligament half way between its attachments to the anterior superior spine and the pubis. It is about 2 centimeters lateral to the femoral pulsation (Fig. 428). Without this finding a diagnosis of iliopectineal bursitis is not justified. This finding alone without confirmatory signs does not justify a diagnosis. However, if definite tenderness on pressure is elicited at the point described, the basis of a diagnosis has been made. [illegible]

[illegible] affected side causes pain in front of the hip region due to the compression of the irritated bursa between the hip joint and the psoas tendon."

Prepatellar Bursa.—McWilliams[34] describes 14 bursae about the knee. He states that the subaponeurotic prepatellar bursa is present in 88 per cent of patients over the lower half of the prepatellar bursa (Fig. 429). Early acute prepatellar bursitis generally will yield promptly to rest, avoidance of further traumatism and warm applications. A circular pad may be placed around the irritated area so as to protect it. In more severe cases aspiration of the bursa and the injection of a caustic substance, such as phenol or iodine, have

been recommended. Carp[35] summarized his study of the conservative treatment in 27 cases of prepatellar bursitis (with final results) as follows:

"(1) Twenty-seven consecutive acute or chronic cases of prepatellar bursitis ('*housemaid's knee*') were studied to determine the end-results of conservative therapy. This consisted in aspiration of the fluid, injection of several cubic centimeters of half strength tincture of iodine into the sac, vigorous massage over the bursa, reinforced adhesive strapping over the sac with the knee in complete extension, and the application of a firm pressure bandage over the knee. (2) The cases were preponderant in housewives. (3) About 65 per cent of the patients gave a history of trauma. (4) About one-third of the cases complained of pain. (5) Swelling of the bursa appeared either immediately after the trauma or after days, weeks, or months. (6) The character of the aspirated fluid depended on the length of time it took for accumulation. In the early cases it was bloody; in the later cases amber- or straw-colored. (7) Aerobic and anaerobic cultures in 11 cases were sterile. (8) In a little more than half the cases small amounts of fluid reaccumulated in an average of ten days. Aspiration of this fluid was employed. A second injection of tincture of iodine in these cases was usually not necessary. (9) An average follow-up of sixteen months in

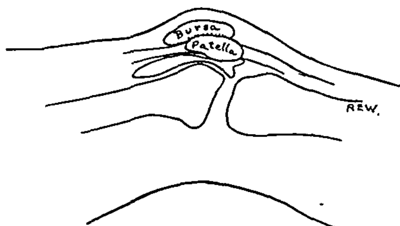


Fig. 429.—Diagram to show the common location of the prepatellar bursa in "housemaid's knee."

24 out of the 27 cases showed no symptoms or reappearance of bursal fluid. In 20 of the 24 follow-up cases the average time for complete disappearance of the fluid was about three weeks."

In cases of infection with suppuration, the bursa should be drained by a generous incision and packed. In the cases of severe chronic prepatellar bursitis, incision and packing may be of benefit, but the treatment of choice is excision of the bursa. This may be accomplished under local anesthesia. A curved incision is made with the convexity upward and enclosing the bursa. The skin flap is retracted downward and the bursa excised as far as possible. It may be impossible to excise the floor of the bursa completely, but as much of the serous surface as is possible may be removed. Any portion which remains should be treated with carbolic acid and neutralized with alcohol. Closure is made without drainage. The patient is kept quiet for several days, and then careful walking is permitted.[36]

Bursitis in the Region of the Tibial Collateral Ligament.—Voshell and Brantigan[37] report on ten cases of this condition, which they believe to be a new clinical entity. Novocain injection was successful in some cases, but excision of the enlarged bursa was necessary in others.

Bursitis in the Region of the Fibular Collateral Ligament.—The identity, diagnosis and treatment of this condition is described by Hendryson.[38]

McWilliams states that there are about ten *bursae of importance about the foot and ankle*. The following are included among them:

Bursa between the Tendons of the Extensor Digitorum Longus and the Prominent Overlying Talus (Astragalus).—This bursa is irregular in extent, and inflammation of it will cause a tender area on the dorsum of the foot.



Fig. 430.—"Bursae of foot, lateral view. Constant sacs indicated by solid lines; occasional formations by broken lines." (Roberts P. W.: Am. J. Surg. 6: 313, 1929.)



Fig. 431.—Medial view of foot showing location of permanent and adventitious bursae. (Roberts, P. W.: J. Bone & Joint Surg. 11: 338, 1929.)

Retrocalcaneal Bursa.—This bursa lies between the tendo achillis and the tuberosity of the os calcis. Excessive walking coupled with traumatism of stiff boots, skating or running is liable to cause inflammation of this bursa, a condition which is spoken of as achillodynia.

Subcutaneous Bursa over the Tendo Achillis.—This bursa likewise becomes inflamed after excessive walking in stiff boots or shoes. The treatment of

this condition (achillobursitis) is the removal of all pressure from the bursa. Zadek,[39] for relief of symptoms due to the bursa either above or below the Achilles tendon, advises excision of a wedge, with the base uppermost, from the top surface of the os calcis.

Inferior Subcutaneous Bursa under the Heel (See Painful Heel).—This bursa, which lies immediately beneath the tuberosity of the os calcis, becomes inflamed with excessive walking, and a *painful heel* results. This condition should be distinguished from the pain caused by low grade inflammation of the insertion of the plantar fascia, which often may be accompanied by calcaneal spurs.

Bursae over the Malleoli.—These bursae are inconstant. When present, the bursa over the external malleolus is spoken of as "tailor's bursa" and may become inflamed by the irritation incident to sitting crosslegged.



Fig. 432.—Showing location of the subcalcaneal, intermuscular and metatarsal bursae, and of those found in the superficial fascia of the sole. (Roberts, P. W.: J. Bone & Joint Surg. 11: 338, 1929.)

Roberts[40] has made a careful study of 50 cases of bursitis of the foot (Figs. 430–432) and makes the following important statements:

"No examination of a painful foot is complete unless careful search is made for the presence of a bursitis. Circumscribed tender areas not due to trauma or infection are suggestive of inflamed bursae. The pain caused by pressure on a sensitive bursa cannot well be mistaken. It is acute and the area of tenderness is definitely limited, although the patient's description of the existing disability may have referred to a general aching and discomfort in the area surrounding the point of tenderness. If the metatarsal bursae are involved, lateral compression of the anterior part of the foot will frequently cause pain, and so will hyperflexion of the toes which causes pressure on the bursae through tension of the overlying soft parts. In examining the sole of the foot, the location of the affected bursa may be determined by the degree of pressure required to elicit pain. Moderate pressure will cause pain if the bursitis is in the superficial fascia and rather deep pressure will be required to elicit a reaction in the

of the malleolus. Passive *motion of the ankle or pressure over the transverse interarticular* space causes no discomfort. In other parts of the foot, as elsewhere in the body, circumscribed areas of acute tenderness, not due to trauma or infection, may be safely considered as indicating a bursitis.

"The treatment of bursitis of the foot differs in no essential from the treatment of bursitis elsewhere. The problem is to protect the distended sac from pressure or to obliterate [illegible] applied with a view of preventing friction is frequently helpful in moderate cases but will prove disappointing if the condition has existed for some time and the symptoms are acute. When conservative measures fail, surgical obliteration of the affected bursae is indicated. This often can be done through a small incision which will permit the vigorous use of a sharp curet, except in cases of premalleolar bursitis where it is better to dissect out the entire fat pad and let the skin collapse over the fibrous expansions covering the joints. Two weeks will be required for convalescence. In the 25 cases operated upon, there have been no recurrences, although 2 were slow in making a complete recovery. Of the 50 cases, 25 *were treated conservatively, 25 were operated upon, 41 were relieved, 9 were improved,* and none were complete failures."

Bunion.—"A bunion is an inflamed adventitious bursa which is formed over the metatarsophalangeal joint of the hallux valgus." (McWilliams)[34] It may develop secondarily to, or coincidentally with, hallux valgus. As will be described presently, hallux valgus is the lateral deflection of the phalanges of the great toe caused by the wearing of too tight, too pointed or too short shoes. The deflection results in a gibbus at the metatarsophalangeal joint which is subjected to a continuous, abnormal amount of pressure. As a consequence, a lubricating sac or bursa will form in this situation. This bursa or bunion most frequently is inflamed and may be exquisitely sensitive.

The treatment of the acutely inflamed bunion consists of removal of pressure by rest in bed or by wearing very large shoes, by employing hot fomentations and, in some cases, by the introduction of a rubber pad with *flanges between the great and second toes. These pads resemble a small* Brewer empyema tube. Their purpose is to correct the phalangeal deflection and minimize the prominence of the gibbus. The most successful type of treatment of bunion is operative. (For details, see the section on Hallux Valgus.)

Treatment of Bursitis in General.—McWilliams[34] has given excellent advice on the general principles of treatment of bursitis. The most important measure is rest, with avoidance of pressure or friction between the inflamed surfaces of the bursa. The latter often may be accomplished by strapping the bursa or by rest in bed. If the bursa becomes very distended, aspiration or repeated aspirations will be of value. Neglected acute bursitis may be transformed into chronic bursitis, or chronic bursitis may develop without the occurrence of an acute stage. Chronic bursitis has been treated by repeated injections of iodine, but cure by this method is uncertain. The best methods of treating bursitis are surgical. The bursa may be incised and packed with iodoform or plain gauze. As the packing is gradually withdrawn, the serous surfaces of the bursa become inflamed and adhere to each other, thus obliterating the bursal cavity. The surest method of all is the complete excision of the bursa. As has been mentioned in connection with prepatellar bursae, complete excision may be impossible. In this case, as much of the bursa as possible should be excised, and the remaining portion should be curetted and treated with a cauterizing agent, such as phenol.

Sprains.—The English writers have given sprains serious consideration. Their tendency is to recommend early pressure dressings and exercise.

Novocain Treatment of Sprains (See the treatment of various sprains).—Leriche and Arnulf[41] believe that "a sprain is the reflex consequence of trauma, and specifically the result of a distortion of the nervous apparatus present in the articular ligaments." They believe that if the nerve irritation is suppressed by local anesthesia, the normal functional state is restored. They have used the novocain injection treatment in all types of sprains and at all stages, but the best results are obtained in simple sprains in the early stages. The after-effects of sprains are also benefited. *x*-Ray examination must of course be negative.

The technic of Leriche and Arnulf is as follows: "(1) Injection of 10 to 20 cc. according to the importance of the articulation, of a 1 per cent solution of novocain in the region of the traumatized ligament. The point designated for the injection is the spot of maximum tenderness but care is also taken to inject the ligament itself. (2) Material ordinarily used for local anesthesia; a fine needle and an ordinary syringe. (3) Ligaments of the knee, wrist, ankle and shoulder are usually easy to locate. For the hip, however, the injection is more difficult. For this articulation one succeeds in avoiding the large vessels by introducing the needle to the neck of the femur, withdrawing it about 1 cm. and then making the injection. The use of a fine, long, flexible needle facilitates the injections, allowing one to surround the osseous tuberosities, thus obviating the necessity for repeated skin punctures. (4) The results are immediate and the attempts of the patient at mobilization in the first quarter of an hour indicate if the injection is sufficient. If the pain and disability still persist, another injection in the region remaining painful is made, so that the total quantity injected does not exceed 25 or 30 cc. After several moments the patient is asked to gently move the joint and quite generally he is astonished to find an almost normal painless movement. Cautiously at first, the patient later moves without hesitation when he no longer feels pain. Ordinarily a single injection suffices, but if not, repeated infiltrations during the subsequent few days are made. (5) Accidents in using this technique have never caused alarm, for the puncture of a blood vessel, which should rarely happen, is quite harmless. In order to be certain that novocain is not injected into a vessel one must withdraw the plunger of the syringe, or be certain that no flow of blood comes from the inserted needle. Injection into a joint cavity likewise incurs no risk providing one has observed the rules of strict asepsis. We should, however, mention one feature: The patient should always be warned to expect increased pain about two to three hours following injection. This is caused by the increase in blood supply to the tissues infiltrated with novocain, but it usually disappears in a short time, and leaves the articulation free from pain."

Hip.—Because of the depth of the acetabulum, the great strength of the ligaments of the hip joint and the overlying muscles sprain of the hip joint is extremely infrequent. The diagnosis is based on a history of trauma and the demonstration of pain under certain motions of the hip. There also may be localized tenderness. The treatment is rest and application of external heat. Aspiration may be necessary (Fig. 433).

Knee. (See the section on Effusion into the Knee Joint.)—*Sprain of the knee* is a term which may be applied to wrenches of the knee joint which cause microscopic injuries to the supporting ligaments and capsule but no gross solution of their continuity.

From their excellent study Brantigan and Voshell[42] conclude:

"The integrity of the knee joint depends upon the muscles and tendons about the knee, [illegible]

fibular collater [illegible]

capsule, collat [illegible]

[illegible]

ments. Hyperextension is controlled by both collateral ligaments, both cruciate ligaments, both menisci, the posterior aspect of the articular capsule, the oblique popliteal ligament, and the architecture of the femoral condyles. Hyperflexion is controlled by both cruciate ligaments, both menisci, the femoral attachment of the posterior aspect of the capsule, the femoral attachment of both heads of the gastrocnemius muscle, and the bone structure of the cond[illegible] flexion. [illegible] no stror[illegible] forward and backward in extension and flexion."

(See the section on Sprains of the Upper Extremity and Ankle and also Injuries to the Knee.)

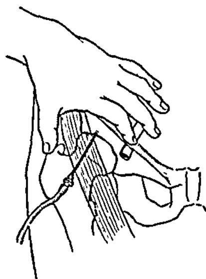


Fig. 433.—Aspiration of the hip joint from in front. The needle is inserted midway between the trochanter major and the intersection of the femoral artery with Poupart's ligament. The needle is anterior to and parallel with the neck of the femur. (McWilliams, C. A., in Lewis, D.: Practice of Surgery, Hagerstown, Md., W. F. Prior Co, Inc.)

The diagnosis of strained knee is made by history of injury by pain induced by certain motions of the knee. A further symptom of sprain of the knee is the presence of effusion of fluid into the knee joint. Excessive fluid in the knee joint is always first apparent proximal to the patella. A sense of fluctuation readily may be appreciated by using the usual three point test. Two "watching" fingers are placed at the lateral margins of the convexity, and pressure is made which will cause the watching fingers to appreciate a fluid wave. A further test for effusion in the knee joint is the demonstration of a "floating patella." The patella is gently forced downward upon the underlying bones, from which it normally is not separated, and on contact with them gives rise to a characteristic click. This test shows that the patella has been forced outward by the excess fluid in the knee joint.

The treatment of sprain of the knee with "water on the knee" includes rest, repeated aspirations (Fig. 435) and early motion. The knee support of Truslow[43] (Fig. 436) is valuable and effective.[44] Adhesive strapping is useful

but the adhesive should not encircle the knee and cause compression of circulation (Fig. 434). In the cases of more severe involvement, if partial rupture of the ligaments is suspected, immobilization in a plaster cast is indicated. (See section on Injuries to the Knee.)

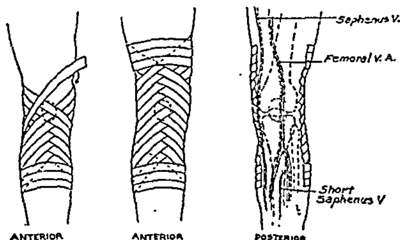


Fig. 434.—Knee supported by adhesive strapping. Note that encirclement of the knee with compression of the circulation is avoided. (Carr, C. R., and Haggert, G. E.: U. S. Nav. M. Bull. 42: 787, 1944.)

Application of a Plaster Cast to the Lower Extremity.—The proper application of a plaster cast to the lower extremity requires a certain amount of skill for the successful treatment and the comfort of the patient. Two assistants

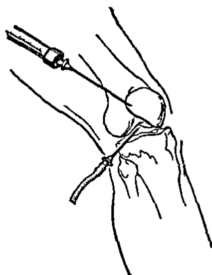


Fig. 435.—Anteroexternal aspiration of the knee joint. The needle is inserted 1 inch to the outer side of the patella. (McWilliams, C. A., in Lewis, D.: Practice of Surgery, Hagerstown, Md., W. F. Prior Co., Inc.)

are desirable. The patient lies flat upon his back, and the foot is held up by an assistant or by suspension in a loop. In cases in which the cast is used to immobilize the knee joint and it is not required to include the ankle or foot, the procedure of Mooney[45] is employed. The skin is painted with compound tincture of benzoin. Long strips of adhesive plaster are applied from the

upper portion of the thigh down to the ankle and continued for 12 to 18 inches more as free ends. After ½ to ⅔ of the thickness of the cast has been applied, the free ends are turned up and incorporated in the last layers of plaster. In this manner the cast is suspended from the skin of the extremity and cannot settle down and cause chafing of the skin in the region of the ankle joint (Fig. 437). The lower extremity is then enclosed in a single layer of smoothly applied stockinet from the dorsum of the foot to as high up in the groin as possible. Owing to the difference in diameter of the thigh and the leg, it may be necessary to use two sizes of stockinet, which may be carefully overlapped in the region of the knee. The extremity is next wrapped with one or more smoothly applied layers of sheet wadding, which are thin

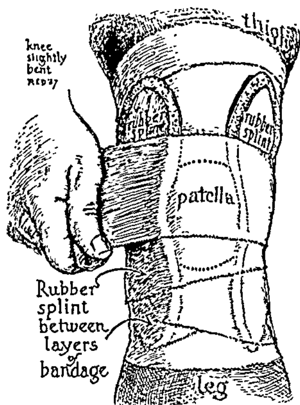


Fig. 436.—Combination ¼ inch sponge rubber and an ace bandage, partly applied to the left knee, featuring the shape and position of the sponge rubber splints. To complete the support, the bandage will be continued to the top edge of its inner layer. (Drawing by Dr. Robert L. Dickinson, New York.) (Truslow, W.: J. A. M. A. 110: 285, 1938)

layers of cotton so prepared that their surface is smooth and that they have various widths. If a snug cast is desired, the sheet wadding is omitted. When it is intended to have the cast rest upon the sides of the malleoli, a method which is less desirable than the Mooney adhesive support, the next step is the encircling of the malleoli with a properly prepared felt pad. This pad is so cut that projections of it rest upon the malleoli, leaving the tendo achillis and the anterior extensor tendons entirely free. It is neatly sewed together at the anterior side. All the edges of the pad are beveled. Next a circular pad is placed over the patella. In the center of this pad, radical incisions are made so there are numerous pointed tongues which, together with the circumference of the pad, are beveled. The wet plaster bandages are now

applied. These are wound around the extremity very smoothly and with sufficient tension to make them snug but not tight. As each succeeding layer of plaster bandage is applied it is thoroughly rubbed by an assistant so as to insure the intimate distribution of the plaster within the meshes of the gauze. Failure to observe this precaution is likely to produce a cast which is weak and which splits apart in layers because of nonadherence between the individual layers of bandage. Any parts of the bandage which may not become sufficiently moistened should be sprinkled with water before they are rubbed. The thickness of the plaster cast is variable. For young active children, where the cast will be subjected to considerable violence, *at least* ½ inch will be

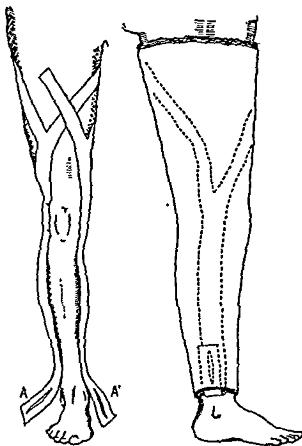


Fig. 437.—Suspension of plaster leg cast by means of adhesive tape applied to the skin. (Mooney, V.: Am. J. Surg. 32: 186, 1936.)

required. For older and more sedentary individuals the cast may be somewhat thinner. When the proper thickness of plaster has been reached, the stockinet at the top of the cast is turned down and fastened by an extra turn of plaster bandage, thus insuring a smooth, rounded top to the cast. For an elderly patient it is helpful to construct a plaster ring at the base of the cast on the anterior side. Stockinet or muslin reins are passed through the ring and give the patient considerable help in lifting the extremity. In the type of cast in which the weight rests on the felt padded malleoli, an arched piece is now cut out from the anterior and posterior aspects of the lower part of the cast (Fig. 438). This is done in order to avoid interference with flexion and extension of the foot. The final revision of the lower end of the cast will be

deferred until the second day, when the plaster will be entirely dry. The stockinet is then turned upward and made fast to the cast by strips of 1 inch adhesive plaster.

Should blisters form either over the tendo achillis or anteriorly, the incisures in the cast should carefully be deepened with a cast knife until the difficulty is remedied.

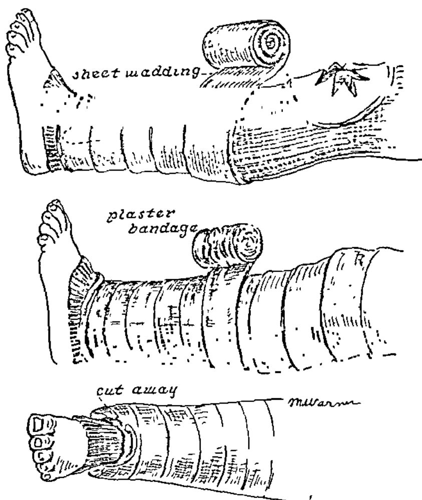


Fig. 438.—Cotton sheet wadding applied over stockinet and felt pads. Some prefer to place the felt pads outside the sheet wadding The plaster of paris bandage is applied over the sheet wadding, care being taken that it is smoothly applied and continuously rubbed during the application. The layer of sheet wadding *may be very thin or entirely omitted.* The cast is cut away in front and in back to allow flexion and extension of the foot. The Mooney adhesive suspension cast is preferable to one which permits the weight to rest on the felt-padded malleoli.

Ankle.—Sprains of the ankle are of very common occurrence. They occur as a consequence of violent "turning" of the ankle. The ligaments are overstretched, and some of the fibers are ruptured. By far the most common variety of sprain of the ankle is that which follows violent inversion of the foot. Here the ligaments most commonly injured are the anterior and middle fasciculi of the anterior lateral ligament (ligamentum talofibulare anterioris and ligamentum calcaneofibulare). Uncommonly the foot may be violently everted when the internal ligament and the anterior and posterior tibiotarsal

ligaments (ligamentum deltoideum) are involved. Smart[46] makes a distinction between the word "strain" and "sprain." He defines a "strain" as a rupture or injury of muscle fibers and a "sprain" as an injury to the joint ligaments and capsule. He states that the latter is the more serious lesion. The symptoms of sprain of the ankle are instant intense pain and very rapid effusion of fluid in the neighborhood of the injury. A swelling the size of a hen's egg may appear in five or ten minutes. The pain occasionally is so severe as to cause the patient to faint. Weight bearing may be impossible. In all cases of sprains of the ankle the possibility of fracture should be suspected, and unless it can be excluded clinically, the ankle should be examined by *x*-ray. The fibula should be carefully palpated for tender areas, particularly in its lower 2 inches. A tender point upon the fibula should arouse suspicion of Pott's fracture, and a roentgenogram should be made. Tenderness and swelling about the ankle joint are present in fracture of the astragalus, and if there is any question a roentenogram should be made. In examination of an ankle for sprain it will be noted that all motions which place the injured ligament upon a strain are extremely painful. In injuries to the external lateral ligament a diagnostic point is that inversion of the relaxed foot is painful. Similarly, in injuries of the internal lateral ligament, eversion of the foot is painful. Hyslop[47] reports 3 cases of peroneal paralysis which were apparently caused by ankle sprains. Recovery took place in from six weeks to six months.

The usual first-aid treatment is the application of cold compresses to reduce the swelling. It is possible that further study of this subject will demonstrate that hot fomentations or hot foot baths, which are most acceptable to the patient, are of equal if not superior value. The congestion induced by the external heat is quite likely to facilitate the dissemination of adventitious effusion. A treatment which is recommended by many and which has proved to be of considerable value in the hands of the writer is the employment of contrast foot baths. Here the foot is first immersed in warm water for a period of five minutes and is then plunged into cool or cold water for thirty seconds or one minute, then being returned to the hot water. This procedure is continued until relief is obtained, as long as an hour or more occasionally being necessary. After the first few hours, warm applications are most suitable. The administration of codeine or morphine may be necessary for the pain. Aspirin certainly has a beneficial influence in the mild cases. Of importance, in the author's opinion, is the placing of the injured extremity at rest, and elevating it 12 to 14 inches. Rest in bed is preferable, but the employment of crutches is indicated for patients who must be up and about.

After an experience with more than 500 ankle sprains, McMaster[48] says: "Immediate and continued active motion and use of a sprained ankle and foot almost irrespective of any local treatment definitely hastens recovery."

The [illegible]

[illegible] ...caine hydrochloride [illegible] ...ed by tender points [illegible] Two per cent procaine hydrochloride solution without epinephrine is used routinely and with it a wheal is made in the skin over the site of injury with a fine needle. The latter is replaced by a larger needle and the underlying injured ligament is injected. All tender points, whether proximal, distal or intervening portions of the ligament, are injected. A search is then made for

tender areas in other ligaments, and these are each carefully injected until no tender or painful areas remain either with palpation or ankle and foot motion. The amount of procaine solution varies from around 10 to 20 cc. There is no hesitancy to use an ounce or more if necessary. Next an elastic bandage is wrapped snugly around the ankle, and the patient is requested to walk around the room. If any pain is experienced, further injection is done. The patient is then returned to activity with instruction to use and move the foot and ankle normally, except for running and jumping. Also it is stressed that while sitting, as at a desk or table, the foot should be moved and not kept immobile in one position even for short periods. The elastic bandage is to be removed and rewrapped by the patient in one to two hours to prevent possible circulatory constriction. Daily and periodic return for check-up is required in all cases." Leinwand[49] has found 2 cc. of 2 per cent procaine, [illegible]

sized vessel; (4) idiosyncrasy to procaine.[50] Alexander[51] has used novocain injections plus adhesive strapping in 500 cases. In 41 cases of ankle sprain in military service treated by novocain injection, Murphy and Postlethwait[52] obtained excellent results in 30 and good results in 10. McLaughlin[53] obtained excellent results by this method in nine tenths of 51 cases in which the patient was seen within twent-four hours after the injury. Into all tender areas about the ankle joint 20 cc. of 1 per cent novocain (procaine) was infiltrated. Injections were repeated if discomfort persisted. This method receives further endorsement by Webber[54] and Scott.[55] Quigley,[56] of the Harvard Athletic Association, says: "While procaine is useful in the treatment of certain minor sprains in nonathletes, the experience of this department for the past ten years, based on the treatment of approximately 75 ankle sprains a year in athletes, has led to the conclusion that it has no place in the treatment of any sprain sustained in contact sport. A sprain is a partial rupture of a ligament. When the protective function of pain is eliminated by procaine and the ligament is subjected to the [illegible]

[illegible] ige. However, Bistrow[58] says: "The principles of treatment of a sprained ankle include: (1) Pressure to limit the swelling, (2) protection to prevent further damage, and (3) encourage- [illegible]

the ankle should be advised. The patient should be encouraged to walk at once within reasonable limits. Stimulation with a faradic current helps the muscles to regain tone. Gentle massage should be given to get rid of the swelling and improve the circulation.

"Although simple sprains heal quickly, more severe sprains may be followed by persistent symptoms and recurrence. Chronic sprains are characterized by pain, muscle atrophy, limitation of movement and synovitis. The patient with a chronic sprain may get into the hands of a bone setter or other irregular practitioner who tells him that a bone is 'out' and proceeds to 'put it back.' What such a practitioner really accomplishes is the breaking up of adhesions which renders the patient more comfortable. This can and should be done more often by the legitimate surgeon.

"For the treatment of the chronic sprain the author advises putting the joint through [illegible]

After twenty-four hours, when the swelling has begun to subside, supporting measures are indicated. A woven bandage ("Ace") may be all that is required. Such a bandage is removed at night, when a hot foot bath may be given. The adhesive strapping in the method advised by Gibney is extremely useful (Fig. 439). The foot is held in its optimum position by either an assistant or by the patient himself holding bandage "reins." It is important that the strapping be put on with the foot held in dorsal flexion. If the external lateral ligaments are involved the ankle should be strapped in a position of

eversion, so as to relax the strain upon the affected ligament. If the internal lateral ligament is involved the foot is strapped in a position of inversion. The alternate longitudinal and transverse strips of adhesive plaster, ½ inch wide, are woven about the ankle joint in the manner pictured in the illustration. Theoretically, these strips should not cross the ankle anteriorly in the midline, because of consequent interference with the circulation. Practically, however, an occasional short overlap does not seem to interfere with the efficacy of the strapping. Should swelling of the foot occur following the strapping, the adhesive "cast" may be cut longitudinally on the dorsum for its entire extent. Galland[59] advises placing a felt pad over the tendon of Achilles before strapping the ankle.

A further very useful procedure which was suggested to the writer by Dr. George Musselman, but for which he claims no originality, is the use of the valgus and varus pads. These are curved felt pads, about 3 inches

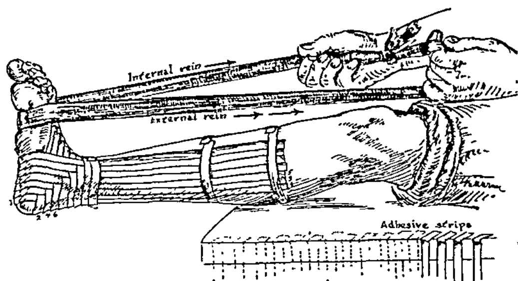


Fig. 439.—Gibney adhesive strapping for sprained ankle. For sprains of the external lateral ligament, stronger traction is made upon the external rein to secure eversion of the foot. For sprains of the internal lateral ligament the opposite procedure is followed.

long at the outer border, which have a tapering edge. One is placed inside each shoe so as to lift up the injured side of the foot and relax the extension on the overstrained ligament on that side. The pads are glued into the shoes* (Fig. 440). It is remarkable to see the often almost instantaneous relief obtained by this treatment. Almost incapacitated patients not infrequently may walk without pain after pads have been placed in the shoes.[60]†

Sprain of the Inferior Tibiofibular Ligament.—Outland[61] says: "By far the most important and most serious ligamentous injury about the ankle is sprain of the anterior inferior tibiofibular ligament, with varying degrees of lateral luxation of the ankle, but unaccompanied by an important bone injury. In the severer grades of this lesion, failure to recognize its true nature and institute proper treatment results in disability all out of proportion to the apparent seriousness of the injury. Injury to the inferior tibiofibular liga-

* For this purpose "Griswold's Family Salve" is useful. It is heated like sealing wax and applied to the pad. Sealing wax may also be used.

† Ethyl chloride spray has been recommended in the treatment of sprained ankles, but the possibility of skin damage would speak against its general use.

ment may occur alone, but it is usually associated with sprains or tears of the internal or external lateral ligaments." Swelling and tenderness are noted over the tibiofibular joint and absence of swelling below the malleoli. The ankle may be loose (the astragalus may be moved sideways), but this looseness may be demonstrated only after 2 per cent novocain injection. In mild cases the patient may walk with proper support. In more severe cases a cast or open operation will be necessary.[62]

Cooperman[63] describes an ankle sprain which he calls "*trucker's ankle sprain.*" He says that this sprain occurs when two men are handling a four-wheel hand truck, one pulling and the other pushing. "If, for some reason or other, one lags and the truck gains momentum, the foot of the man who is pulling is caught and becomes wedged in between the platform of the truck and the floor. The foot is usually in a position of plantar flexion

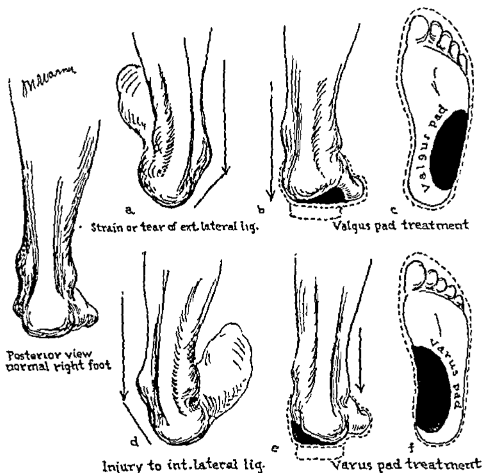


Fig. 440.—Treatment of a sprained ankle by means of felt pads glued inside the shoe. The pad relaxes the strained ligament.

(the heel raised and the body weight on the toes) or it may be flat upon the floor. In either event, the violence is from behind exerted upon the back of the lower leg which tends to force the foot backward and the leg forward. In the attempt to extricate it from this position, the foot will be forced sidewise and the lateral ligaments, either the internal or external, will be sprained.

"The structures involved in the injury are the tendo achillis, the tendons of the tibialis posticus and peroneus longus, the capsular and lateral ligaments of the ankle joint and the interosseous ligament between the astragalus and the os calcis. A sprain of the capsular ligaments occurs at all of its attachments to the margins of the lower borders of the

pushed
agalus.

The head of the astragalus is forced downward and inward upon the scaphoid, carrying the latter with it. The strong inferior calcaneoscaphoid ligament, the long and short plantar ligaments, are strained and the foot as a whole is elongated. The midtarsals and metatarsals receive the impact and are jammed against each other. The force then is finally dissipated in the metatarsal heads and toes. Occasionally, a Stave fracture of the base of the first metatarsal may occur."

The symptoms are pain, tenderness and swelling. In the milder cases strapping is sufficient treatment, and the patient may return to work. In the more severe cases the ankle is immobilized in a plaster cast for ten days in dorsal flexion and slight supination and then given baking and massage.

The author has seen complete rupture of the ligamentum laciniatum, which is just below the internal malleolus, with dislocation anterior to the internal malleolus of the tendon of the flexor digitorum longus pedis. The treatment was fixation of the ankle in inversion and slight plantar flexion. The tendon was readily returned to its compartment.

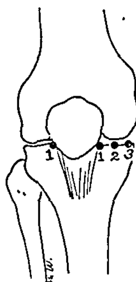


Fig. 441.—Points of tenderness about the knee joint in certain injuries. Tenderness at point 1 on full passive extension, with swelling on each side of the ligamentum patellae, suggests a tender postpatellar pad. Tenderness at point 2 suggests injury to the anterior portion of the internal semilunar cartilage. Point 3 is the usual point of tenderness in sprains of the internal lateral ligament. (Jones, R.: Injuries to Joints, ed. 2, London, Oxford University Press.)

Toes.—Sprains of toes are relatively uncommon and occur chiefly as the consequence of blows upon the ends of outstretched toes. Most of those cases will require *x*-ray examination for the elimination of fracture. Simple strains yield promptly to rest and external heat.

Acute Suppurative Synovitis and Arthritis.—The treatment of this grave condition is a major surgical problem.

Injuries to the Knee.—In addition to sprains of the knee, which have been described above, several other injuries may be mentioned. Sir Robert Jones[64] has emphasized the importance of the elicitation of tenderness at certain points about the knee joint in making the diagnosis of knee joint injuries (Fig. 441). As emphasized by Kernwein and Kelikian,[65] it is well to remember that pain in the knee may be due to pathologic conditions in the hip joint or femur. (See Effusion into the Knee Joint and Sprain of the Knee.)

From an experience with several thousand cases of derangements of the knee joint in over 600 of which operation was done, Levinthal[66] has evolved the following classification of lesions of the knee joint: "Internal derangements:

"(1) Lesions of the menisci (sem
(internal semilunar cartilage), (b)
cartilage), (c) cysts and tumors of
bodies: (a) osteochondritis dissecans (including patellar chondromalacia), (b) osteochondromatosis, (c) osteoarthritic bodies, (d) chip fractures. (3) Lesions of the fat pad: (a)

joi
(a)
(7)
Tumors: (a) xanthoma (b) giant cell tumor, (c) synovioma (d) sarcoma.

Injuries to the Semilunar Cartilages.—The semilunar cartilages of the knee joint are subject to all grades of injury, varying from minor fractures or traumatisms of one or both cartilages to severe fractures or complete avulsion of the cartilage with dislocation. Of the fractures of the internal semilunar cartilage, the "bucket handle" type is the most common.[68] Injuries to the semilunar cartilage are most frequently caused by a forceful, adventitious twisting movement of the knee with the foot fixed. On the other hand, injury may follow the most trivial and ordinary movement.

In 34 cases of torn cartilages
13; twists
zounis'[70]
golf, basketball, skating, wrestling, hockey and running, 53; (2) fall from height, thrown

by a metal spike, 1; (9) injured knee, no other data, 5; (10) no history of injury, 20; (11) no records, 5.

Timbrell Fisher[71] divides these injuries into two classes. In the first the symptoms are severe from the beginning, and recurrences usually tend to become more frequent but are associated with less reaction. The patient experiences a sudden twist of the knee, suffers severe pain on the inner or outer side of the joint and falls to the ground. In the great majority of these cases there is no interference with flexion, but there is inability to extend the leg or joint by some 10 to 20 degrees. The joint locking may be momentary or absent. There is rapid effusion of joint fluid, and attempts to extend the leg are painful. "On palpation, there is, as a rule, well-marked tenderness in the situation of the anterior end of the semilunar due to the tearing of the weak anterior attachments, and hemorrhagic effusion into the loose connective tissue separating it from the aponeurotic capsule. Tenderness is also frequently present over the inner border of the tibia to the inner side of the ligamentum patellae." In the second class the symptoms are slight at first but gradually become more marked until definite locking occurs. There may be a history of recurrent joint effusion, followed by a sensation of weakness

or attacks of "giving away" of the knee before the true locking occurs. "There may be definite tenderness over the anterointernal border of the tibia, or over a semilunar cartilage. The best way to elicit the latter is to place the thumb over the interarticular interval a little to the side of the ligamentum patellae when the knee is flexed. On pressing backwards the patient may not necessarily complain of pain. If the surgeon will then, keeping his thumb in the same position, slowly extend the leg, the anterior end of the cartilage will, towards the end of extension, come in contact with the thumb and the patient will experience pain." (Fisher)

The internal semilunar cartilage is more frequently injured than the external one. In Campbell's[72] series of 108 derangements of the semilunar cartilage there were 19 of the external and 89 of the internal semilunar cartilage. Henderson[73] reported 234 cases of derangements of the internal semilunar cartilage and 22 cases of derangement of the external semilunar cartilage.

From experiments on dogs King[74] concluded: "1. Tears which are limited to the semilunar cartilage probably never heal. 2. A torn meniscus can be healed by connective tissue if the tear communicates with the synovial membrane laterally. 3. A complete transverse or oblique tear results in some separation of the fragments, but the intervening space fills in with connective tissue arising from the synovial membrane. This connective tissue is quite firm in three weeks, which suggests the length of time necessary for complete fixation in these cases. 4. If the meniscus is partially torn from its peripheral attachment, it heals in normal anatomical position without difficulty."

King[75] describes other animal experiments as follows: "A complete extirpation of the internal semilunar cartilage was done on 4 knee joints, subtotal extirpation on 2, and partial excision on 2 others. In 3 cases the joints were immobilized for 11, 7, and 3 days' time. The joints were reopened 8 to 14 weeks later. In every case the extirpated cartilage was replaced by a semilunar disc of firm glistening tissue which grossly was similar in every way to true fibrocartilage. Microscopically this was found to be connective tissue. In 1 case a few cells, suspiciously like cartilage, were seen. Granular degeneration of the articular cartilages of the medial tibial and femoral condyles was a uniform finding in each of these experimental cases."

Fisher[76] says that every original displacement should be treated upon the following principles:

1. Accurate reduction by manipulation of any existing block to full extension. This should be performed as early as possible and may, though generally does not, require the use of an anesthetic. "The patient should be supine on the bed or couch. In the case of the right knee, the practitioner stands upon the outer side, grasps the patient's right foot firmly, and with the left hand steadies the knee. The knee is fully flexed, whereby the grip of the femoral condyle upon the displacement of the cartilage is relaxed. The leg is then abducted as much as possible, thereby opening up the inner side of the joint. Next, the [illegible]

[illegible] the leg is internally rotated, it is suddenly extended, and an audible 'snap' often reveals the fact that the displacement is reduced. In the case of the left knee the position of the hands is reversed." (Fisher) In cases of recurrent displacement the patient often will lie down upon th[illegible]

[illegible] may occur if physiologically possible. A firm bandage should be applied over a cotton pad which is placed [illegible]
Active movements of [illegible]
bearing should be per[illegible]
bed. Gentle, active movements of the knee will be instituted on the tenth day. The patient will begin to walk cautiously, but with great care, avoiding any movements which will

cause outward rotation of the leg upon the fixed thigh or inward rotation of the thigh upon the fixed leg. The raising of the inner side of the sole of the shoe will be valuable in taking off strain from the internal lateral ligament. (Fisher)

3. The prevention for several months of strain upon the newly formed reparative tissues.
4. The preservation during this treatment of the nutrition of the joint structures and of the tone of the muscles which act upon the joint.[77]

Galeazzi[78] believes that the crucial ligaments and the semilunar cartilages form a functional unit and that coexistent crucial ligament lesions with cartilage lesions are often unrecognized. Careful instructions for the diagnostic inflation of the knee joint for purposes of x-ray examination are given by Bernstein and Arons.[79]

Murray[80] says: "We treat all first meniscus lesions conservatively, *if possible.* Only those which evidence locking of the joint, and in which the locking cannot be reduced under an anesthetic, are urged to undergo primary operation. The others, those which have not locked, and those in which reduction of the locking has been possible, are aspirated if the hemarthrosis is large, and are then placed in extension in a circular plaster from groin to ankle. This is applied over stockinette only, with thin felt strip padding about essential bony points. The patient from then on is urged to walk about as much as possible on the extremity, using crutch or cane support for only as few days as possible, and to practise quadriceps contraction exercises at as nearly hourly intervals as possible for the next four weeks or so. If at all possible, he is returned to his ordinary occupation during this time. At the end of this period the circular plaster is removed and the natural exercise of the

in no uncertain terms on that score. Three hundred sixteen clinically certain meniscus injuries so treated recovered completely without operation and without recurrence during the follow-up period. We are certain that in many of these cases, had immobilization been practised without the stress on use and exercise as the essential feature of treatment, relative instability of the knee would have resulted with secondary joint lesions leading to prolonged disability, and in some cases, the need for late operative procedures for the relief of these secondary lesions.

"If, following conservative treatment such as described above, a recurrence of symptoms occurs, or if primarily the locked knee cannot be made to extend, operative treatment is initiated."

Lantzounis[70] says: "Because of the impossiblity of knowing the exact pathologic condition immediately following any trauma to the knee joint, nonoperative treatment was adopted for the acute cases except when there was irreducible locking."

[illegible] level with [illegible] of [illegible] val [illegible] rti- [illegible] ssue [illegible]

Hypertrophy of the Infrapatellar Fat Pad (Hoffa's Disease).—In reporting 2 cases of this condition, del Valle and Satanowski[88] say:

"In 1903 Hoffa encountered a case of marked hypertrophy of the adipose tissue located beneath the patellar ligament. In 1904 he reported seven similar cases, in all of which an operation was performed. Since then the condition has been known as 'Hoffa's disease.'

"In one of the two cases reported by the authors the disease followed a severe trauma, and in the other it was due to syphilis. Hoffa contended that trauma was the only cause, but since his report cases due to other causes such as tuberculosis, the formation of a true lipoma, and syphilis have been recorded.

"The clinical picture is characteristic. After trauma or during the course of a chronic disease process the patient begins to complain of progressive fatigue and finally of pain in the affected knee. The pain occurs only when the knee is used. Progressive limitation of extension then results from interposition of the hypertrophied fat between the articular surfaces. This makes the patient walk with his knee partially flexed and bearing his weight on the metatarsophalangeal joints with the foot in the equinus position.

"Examination reveals: (1) Hypertrophy of the fatty ligament producing a pseudofluctuant and painful swelling on both sides of the patellar tendon, which may be exaggerated when the patient stands, (2) absence of bony changes around the joint, (3) painful limitation of extension with normal flexion, (4) atrophy of the quadriceps, and sometimes (5) the presence of a roentgen-ray shadow.

"The prognosis depends upon the treatment. If the patient is untreated, he remains crippled. The treatment indicated is surgical removal of the tumor mass. Physical therapy and medical treatment have no effect on the condition. In the treatment recommended by the authors the fat pad filling the retropatellar space is removed through a parapatellar incision made on the lateral aspect of the knee. The fat pad is found to be loosely attached to the posterior surface of the patellar tendon and the upper end of the tibia, but fixed firmly to the articular capsule. Three prolongations at its upper end are severed as near their insertion into the meniscus as possible. This procedure opens the knee joint. No attempt is made to close it. After closure of the aponeurosis and skin, the knee joint is immobilized for twelve days, and at the end of that time massage and active and passive motion are begun. Complete recovery usually results within two or three months." Ossification of the infrapatellar bursae and fat pad has been reported by Robillard.[89]

Injuries to the Cartilage of t[illegible] lage of the patella among 159 [illegible] of the cartilage. Soft crepitus [illegible]

Injuries to the Lateral Ligament of the Knee Joint. (For the tests see the previous section on Sprains of the Knee.)—The lateral ligaments of the knee may be injured by blows from either side when the foot is held in a joint fixed position. This trauma may occur when a football player is tackled about one knee when running with the opposite leg off the ground. Most commonly the internal lateral ligament (ligamentum collaterale tibiale) is injured. In testing for injuries to the lateral ligaments the lower extremity is grasped at the knee and ankle; with the knee held fixed the ankle is moved sidewise (Fig. 442). Ordinarily the knee joint is rigid and will resist this motion, but in injuries to the lateral ligaments an abnormal motion, which generally is accompanied by pain, is readily apparent. In case there is severe rupture of a lateral ligament of the knee, the abnormal lateral mobility may be as much as 30 degrees. According to Jones and Lovett,[91] "Injuries to the internal lateral ligament are more serious than to the external, for the latter

is never complicated with a displacement of the meniscus." Too much importance cannot be laid upon the necessity of keeping ligaments at rest until the tissues have consolidated. Rupture or stretching of the internal ligament is often the origin of cartilage displacements which may be traced to early passive and active movements. In cases in which the injury to the lateral ligaments is such as to permit lateral deviation of the leg of not more than 10 degrees, a cure may be effected by immobilization in a plaster cast, followed by physiotherapy. In severe ruptures of the lateral ligaments of the knee joint, major surgical repair will be necessary. It has been emphasized by Harbin[92] that in complete lacerations of the internal lateral ligament and capsular tears, early surgical correction is preferable to fixation and the employment of apparatus alone.

An operation is generally advisable in cases of chronic displacement.[93]

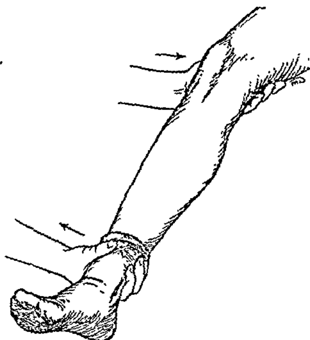


Fig. 442.—Test for injury to the internal lateral ligament of the knee. The test is reversed when the external ligament is examined.

Injuries to the Crucial Ligaments.—In violent traumatism of the knee joint, one or both of the crucial ligaments (ligamentum cruciatum anterius and posterius) may be injured. The diagnosis of injury to the crucial ligament is made by the ability to move the leg anteriorly and posteriorly upon the thigh at the knee joint (Figs. 443 and 444). This very serious injury of the knee joint will require major surgical treatment.

Loose Bodies in the Knee (Joint Mice; Rice Bodies; Corpus Oryzoideum) (See Osteochondritis Dissecans).—Loose bodies in the knee joint may be of several types. In addition to the dislocated semilunar cartilage just described, the knee joint may contain single or multiple free bodies. In 50 cases of movable bodies in the joints Schum[95] found that in 48 there was evidence of previous trauma. Brezovnik,[96] who found a free joint body measuring 7.4 by 4.5 by 1.3 cm. in the knee joint of a man 41 years of age who had

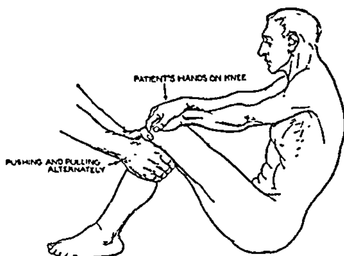


Fig. 443.—Test for rupture of the posterior crucial ligament. If the knee is held steady in 90 degree flexion, the posterior ligament is tense, and backward motion of the tibia on the femur is prevented. If the ligament is ruptured, the tibia may be moved backward on the femur. (From Forrester, C. R. G.: Imperative Traumatic Surgery, New York, Paul B. Hoeber, Inc., 1929.)

injured the knee in a fall six and a half years previously, believed that the finding of articular cartilage bordered by osseous spongiosa in a free joint body may be regarded as an indication of the traumatic origin of the free body. Liger[97] believes that the chemical reaction is of importance in the causation of free bodies in the joints.

Rice bodies are small bodies in the joint cavity which may be very numerous. They may possibly arise from detached portions of synovial fringes. In the study of a case of tuber-

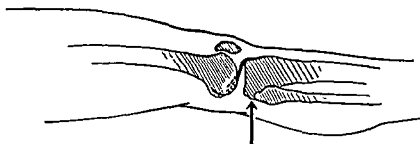


Fig. 444.—Test for rupture of the anterior crucial ligament. The anterior crucial ligament is tense when the knee is extended. The ligament extends from the anterior edge of the tibia to an extensive insertion at the posterior part of the medial aspect of the lateral femoral condyle. When this ligament is ruptured the tibia may be moved forward on the femur when the knee is extended.

culosis with positive guinea pig inoculations, Rogers[98] found that the rice bodies were composed of tuberculous material. They are first attached to the wall of a tuberculous

and aseptic precautions When the bodies have slipped back into the cavity of the joint, their removal is a major surgical operation. Extreme conservatism must be exercised in making the diagnosis of loose bodies in the knee joint. The existence of crepitus and of some interference with joint motion is not sufficient for this.

Myositis Ossificans.—The deposition of bone in muscle is called myositis ossificans. Its cause is occasionally, but not always, traumatic. Noble[99] has classified myositis ossificans into three types: first, progressive; second, myositis ossificans circumscripta; third, a localized (traumatic) type of myositis ossificans. Thompson[100] says: "The progressive type is confined to young individuals, one and then another muscle progressively becoming involved with relative increasing severity with respect to discomfort and restricted function. . . . The second type includes rider's bones and exercise bones, and has as an etiologic factor repeated injury and irritation over a long period of time to a limited region. Third, the localized type is a true traumatic condition in which there has been tearing of muscle tissue, hemorrhage, and perhaps injury to the periosteum and muscle attachments thereto." Pack and Braund[101] report on 3 cases of the development of sarcoma in myositis ossificans.

In the prophylactic treatment of myositis ossificans attention must be directed to contusions causing hemorrhage in muscle. Thorndyke[102] says: "Treatment necessitates the immediate application of cold and a compression bandage to control hemorrhage, and later heat to aid in the absorption of the hematoma. Of great importance is the avoidance of massage on all severe and tender muscle contusions. . . . Operative removal of the ossification is indicated only in those cases in which it occurs near a joint in the origin or the insertion of a muscle, where joint function is permanently impaired, and then only from twelve to twenty-four months after the injury." Geschickter and Maseritz[103] believe that "the conservative form of treatment is often preferable to the radical form. Postoperative recurrences are common, especially if surgical removal of the tumor is undertaken before six months, or if resection is not complete." Bowers[104] stresses the necessity of operation in the traumatic form of myositis ossificans in cases of nonabsorption and disability. Wagner[105] has improved or cured myositis ossificans circumscripta by the administration three times daily of 10 drops of a 25 per cent solution of hydrochloric acid—and later 12.5 per cent solution. The extremity is also treated with Bier's hyperemia. He says massage and passive movement have no place in the treatment.

Calcification of the Tibial Collateral Ligament (Pellegrini-Stieda's Disease).—In this condition a semilunar-like bone in the region of the internal condyle of the femur makes its appearance in the roentgenograms three or more weeks after an injury to the knee (Fig. 445). The process is essentially a metaplasia of ligamentous tissue to bone not unlike myositis ossificans. The metaplasia is initiated by trauma, such as a sprain or contusion. Sabadini[106] believes this condition is a true "molecular" fracture at the femoral attachment of the tibial ligament. The pain in and over the medial aspect of the knee joint may be constant, and flexion and extension of the knee joint are limited. Nachlas and Olpp[107] stress the coexistence of chronic arthritis of the knee. The treatment includes diathermy, heat and immobilization. If these measures are unsuccessful and symptoms persist, excision of the bone formation may rarely be indicated.

Developmental Anomalies of the Patella Mistaken for Fracture.—Adams and Leonard[108] have reported 3 cases of developmental anomaly of the patella in which a diagnosis of fracture was made. In the cases reported in the literature and in these authors' cases, the anomaly was constant in its roentgenographic appearance. The portion of the patella involved is always the outer and upper quadrant. This may consist of one or two separate fragments. The general contour of the patella is not distorted. The borders of the fragment are of cortical bone, and its body of the same structure as the patella. Between the fragments there is a definite space. In the great majority of cases the anomaly is bilateral. A similar anomaly has been found in one of the sesamoid bones, beneath the head of the first metatarsal. In the differential diagnosis between the anomaly described and fracture, the characteristic outline of the fragments must be borne in mind. In the anomaly the outline is smooth and is formed, as stated, by cortical bone, while in a fracture the edge is serrated. Fractures seldom occur in the upper and outer quadrant and have a different clinical history. The anomaly is usually bilateral, while fracture is more commonly unilateral. The differential diagnosis may be made from a roentgenogram. Adams and Leonard



Fig. 445.—Pellegrini-Stieda's disease. (Rachlin, N. H.: J. Bone & Joint Surg. 16: 716, 1934.)

conclude that anomalies of the patella are more common than is generally supposed. Of a series of 63 cases diagnosed as fractures of the patella in the course of a year, 3 per cent were found to be cases of congenital anomaly.

Patella partita is characterized by separation of the patella into two or more fragments.[109] [illegible]

[illegible] per cent. The higher figures were based on anatomic

studies and the lower ones on roentgenologic investigations. Fabellae seem to take part in pathologic processes. Some seem to become arthritic; some become involved in general metabolic disorders, as gout; some can be fractured, while others become involved in what is described as osteochondritis. A rare lesion is the pinching of the fabella in the knee joint, which is possible due to a herniation of the posterior capsule.

Dislocations of the Lower Extremity.—Dislocations are far less frequent in the lower extremity than in the upper, the proportion being as about one to fifteen. Stimson found more dislocations of the hip than of any other joint of the lower extremity, not excluding the phalanges. The latter, however, rank second in frequency and the semilunar cartilages, knee and patella, third, fourth, and fifth, respectively. Because of the great strength of the ligaments about the hip joint, extreme violence is necessary for its dislocation.

Hip Joint.—Four forms of hip joint dislocations are usually described (DaCosta): (1) upward and backward on the dorsum of the ilium, (2) backward to the border of the sciatic notch, (3) downward into the obturator foramen and (4) inward onto the pubes. Oscar H. Allis suggests the following classification:

Low thyroid
Midthyroid
High thyroid } All present abduction and outward rotation.

Reversed thyroid:

Low dorsal
Middorsal
High dorsal } All present adduction and inward rotation.

x-Ray examination should be made in all cases of suspected dislocation of the hip, because the dislocation may be accompanied by fracture of the head.[114] The reduction of a dislocated hip may be difficult. The Stimson and Allis methods of reducing posterior dislocations are shown in figure 446. De Yoe[115] suggests the following method:

"The patient is anesthetized lying on his back and is so placed that the buttocks are at the end of the table. An assistant holds the normal leg horizontally or it may be placed on a small table of the same height as the operating table. The pelvis is now strapped or firmly held to the table by the assistant. The operator takes the dislocated leg, flexes the thigh, and with his back against the end of the table and against the patient's buttocks, brings the dislocated leg over his shoulder. The operator's shoulder is now under the popliteal space, the knee is flexed, and the back of the patient's calf lies against the operator's [illegible]

no longer restricted."

Reduction should not be attempted without a thorough study of the type of dislocation and the possible relationship of the rent in the capsule and of the position of the head of the femur to the Y ligament. Reduction should be attempted only with the patient under complete general anesthesia and often is very difficult.

Banks[116] says: "Any patient who sustains a traumatic dislocation of the hip may develop late changes in it, due to aseptic necrosis of the femoral head. Of the forty-three recorded cases in older children and adults, thirty-nine have resulted in deformed and painful or ankylosed hips. In each of these instances, the head had undergone extensive collapse or fragmentation before the patient returned for medical care after the period of

apparent recovery, or before the primary pathological condition was recognized. . . . Whenever possible, the extremity may be protected from weight-bearing by means of crutches for four to six months after the postreduction period of immobilization or recumbency. If the femoral head undergoes uniform atrophy of disuse and no density difference develops between it and the then osteoporotic living bone of the shaft and the ilium, as shown by roentgenograms, the patient may resume full weight-bearing with the likelihood that the head has remained alive, although roentgenographic follow-up should continue for an additional twelve months. However, if the head is thus shown to be necrotic, early protection can be provided and continued until serial roentgenograms show final revascularization and replacement by new bone." Protection from weight bearing is also advised by Kleinberg[117] and Walker.[118] Traumatic dislocation of the hip has been reported in a boy of 6 years.[119]



Fig. 446.—Two methods of reducing posterior hip dislocation. 1. Stimson's, or gravity method, the simplest, weight of limb supplemented by downward thrust in popliteal space. 2. Allis' method: flex, lift rotate in and out, lift again. (McWilliams, C. A., in Lewis, D.: Practice of Surgery, Hagerstown, Md., W. F. Prior Co., Inc., 1929, vol. 3)

Knee Joint.—Dislocation of the knee is uncommon and requires marked violence for its causation. Four forms are usually described—forward, backward, outward and inward. Ferguson and Allen[120] report division of the common peroneal nerve in a complete medial dislocation of the knee. Reduction generally is readily accomplished under general anesthesia. A dislocation of the knee joint which remains unreduced for a certain length of time will cause pressure on the popliteal vessels and may give rise to gangrene of the extremity requiring subsequent amputation. When there is extensive laceration of the ligaments of the knee joint, the suture of these ligaments, a major surgical operation, is indicated. When extensive laceration of the ligaments of the knee joint does not seem to be apparent, immobilization of the extremity in a plaster cast for six weeks is indicated. After this time gentle active and passive motion is indicated, together with the wearing of the hinged cage brace of the knee joint. Conwell and Alldredge[121] report

7 cases of complete dislocation of the knee, with gratifying results obtained from treatment by immediate reduction under general anesthesia and prolonged immobilization.

Patella.—Dislocation may be either outward or inward. The diagnosis is readily made by the abnormal prominence of the patella at one side or the other and by the inability to flex the knee joint. Balensweig[122] reports a case of unreduced dislocation of the patella of twenty years' duration which was cured by operation. Irreducible lateral dislocation of the patella with rotation has been reported by Inman and Smart.[123] Open reduction was required. The dislocation generally may be reduced rather easily and without anesthesia. The instructions of Speed[124] are to "flex the thigh on the body to relax the quadriceps; fully extend the knee to relax the patellar tendon, and to allow the patella to take its position as high up on the condyles as possible; manipulate the patella by pushing it inward to make it ride over the edge of the condyle; grasping the front of the thigh firmly in the hand to aid relaxation, push down the quadriceps. The leg is then flexed and the patella assumes a normal position." The knee joint is immobilized for three weeks, after which careful active and passive motion is instituted. A properly fitted brace which prevents inversion of the knee and eversion of the foot will be useful in the after-care if there is any tendency to recurrence.

Recurrent dislocation of the patella is often spoken of as "*slipping patella.*" It is usually outward, is more common in females, and there may be a hereditary relationship to the etiology. Ober[125] says: "Chronic slipping of the patella may result, after many years, in a degenerative arthritis of the knee." *Henderson makes the following diagnostic test: Have the patient sit* so that the heel of her leg can be conveniently placed on the operator's knee. Then gently push the patella outward a little and flex the knee. If a slipping patella is causing the trouble, the patient will usually say that the sensation felt is somewhat similar to that experienced when the giving away of the knee occurred, and she will become quite apprehensive if pushing outward on the patella is persisted in. Surgical treatment is practically always necessary for recurrent dislocation of the patella. A study of the end-results after various types of operations was made by Houkom.[126]

Semilunar Cartilage.—This type of dislocation has already been described.

Head of the Fibula.—Dislocation of the fibula at the superior tibiofibular articulation rarely occurs. This injury may be very difficult to reduce and may require open operation. Many dislocations, however, will respond to the manipulation of flexing the leg upon the thigh to remove the pull of the biceps and pushing the bone in place. The writer has seen the dislocation corrected when the patient moved the leg and started to walk upon it. The anterior tibial nerve (nervus peroneus communis) is in close relationship to the head of the fibula, and care must be taken not to injure or put pressure upon it. After reduction the extremity should be immobilized in plaster of paris with the leg partly flexed for four to six weeks (Speed). Apparently recovery may occur, after reduction, without any further treatment. Burman,[127] in reporting a case of subluxation of the head of the fibula, says that 44 other cases have been recorded in the literature. Schwartzhaupt[128] reports a case of forward dislocation of the head of the fibula with easy reduction under anesthesia. In the 2 cases reported by Macklin and his associates,[129] reduction was obtained by dir sure on the proximal end of

the fibula with the knee flexed. One patient was treated with rubber sponge pressure and the other with a cast (for two weeks).

Ankle Joint.—Dislocations of the ankle joint without fracture are extremely rare.[130] In fractures of either external or internal malleoli, external or internal lateral dislocations of the astragalus upon the lower end of the tibia are extremely common. In case of fracture of the posterior malleolus of the tibia, posterior dislocation of the astragalus upon the tibia is common. Anterior dislocation is uncommon. The reduction of the dislocation is accomplished coincidently with the reduction of the fracture and often with but little difficulty. In cases of posterior dislocation with fracture of middle malleolus.

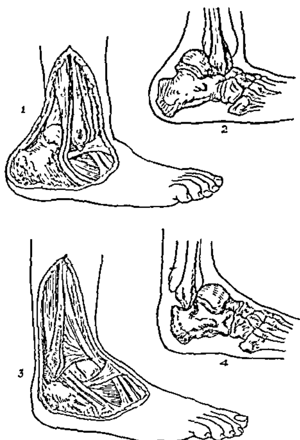


Fig. 447.—1, 2, Outward and posterior astragaloid dislocation. 3, 4, Inward and anterior dislocation. (McWilliams, C. A., in Lewis, D.: Practice of Surgery, Hagerstown, Md., W. F. Prior Co., Inc., 1929, vol. 3.)

section of the tendo achillis may be required (see below). All dislocations, and especially those about the ankle joint, should be reduced immediately. The deformity of the dislocation may cause abnormal pressure on important arteries and bring about gangrene of the extremity distal to the injury unless reduction is promptly effected. Elmslie[131] reports 4 cases of recurrent subluxation of the ankle treated by operation.

Tarsal Dislocations; Subastragalar Dislocations.—In subastragalar dislocations there is separation of the astragalus from the os calcis and the scaphoid. Reduction of this dislocation, which may be often difficult, will always require general anesthesia. After reduction, immobilization in a plaster cast for three or four weeks will be indicated. Smith[132] reported

7 cases of subastragalar dislocation with good results following prompt reduction. Conwell and Alldredge[133] state: "A case of compound comminuted fracture-dislocation of the astragalus is reported in which reduction was performed without the occurrence of necrosis, and the functional result was satisfactory." The writer has seen a tarsal dislocation readily reduced with the patient under ether anesthesia. Reduction, however, could not be maintained without the application of pressure upon the adjacent bone sufficient to cause pressure necrosis. To avoid the later complication it was necessary to hold the dislocated part in position by traction and suspension by adhesive plaster upon the sole of the foot, so arranged as to pull the foot upward in dorsal position. Operation may be required. A subastragalar dislocation of the foot has been reported by Atsatt.[134] In a case of dislocation of a single cuneiform bone, Clark and Quint[135] were obliged to chisel off the projecting bone. Two cases of talonavicular dislocation are reported by Miller and Kolb.[136] In one case treatment consisted of closed reduction and application of a cast; the other dislocation required open operation.[137]

Metatarsal Dislocations.—Dislocations of the tarsometatarsal joints are uncommon. Quénu and Küss[138] classify them into divergent and spatular types. Examples of each are reported by Easton. In *Morton's disease* (*metatarsalgia*) there may be subluxation of the fourth metatarsal. In this condition there is pressure upon the subjacent sensory nerve, causing an extremely painful foot. Hertzler[139] contends that the nerve pressure theory advanced by Morton to account for metatarsalgia has no facts to substantiate it and that this condition is due to inflammation of one or all of the three sets of bursae in the region of the metatarsophalangeal articulation. He advises the obliteration of the bursae by curettement.[140] Jones[141] found that the sudden severe neuralgic pain characteristic of the condition was due to a compressing of the nerve twigs by the metatarsal heads, which had fallen out of their proper position in the transverse arch and nipped the nerves between the head of the metatarsal bone and the ground. According to this author, the symptoms are characteristic and definite: "The patient experiences a burning cramping pain in the front of the foot, generally under the fourth metatarsal head, often under the third, and, less commonly, under the second. The pain is sometimes preceded by a sensation of slipping. It occurs usually in walking, sometimes in standing, and very rarely in bed. The pain is very intense, and the patient almost immediately learns to relieve it by removing the boot, flexing the toes, and rubbing the front of the foot, and squeezing the metatarsals together, while other patients place the bare foot on a cold surface to obtain relief." The treatment may be difficult. Jones places a bar of leather across the foot under the tread well behind the head of the metatarsals. This method generally relieves but may not cure the condition. An accurately made arched plate pressing into the hollow of the foot behind the heads of the metatarsals may give relief. The adjustable metatarsal pad of Milch[142] is simple and may be of service (Fig. 448). A properly shaped and placed pad of wood, leather or felt attached to the inside of the sole of the shoe is often very valuable. In some cases a painful neuroma is present, and cure will require its excision. McElvenny[143] believes that "Morton's toe" is "caused by a tumor involving the most lateral branch of the medial plantar nerve." He says: "Careful palpation will usually reveal the tumor, which

lies high in the web between the third and fourth toes." McElvenny has operated in 11 of these cases and removed a tumor in each case, affording a permanent cure. He favors a web splitting approach. Similar results have been reported by Betts.[144] In cases of severe dislocations, resection of the heads of the metatarsals may be necessary. Narat[145] reviews the literature on dislocations of the metatarsal bones and reports an extremely interesting case in which "(1) The bones were dislocated in two different directions; there was a plantar dislocation of second, third, and fourth metatarsals and dorsal dislocation of the first and fifth metatarsals. (2) In addition to a plantar and lateral dislocation of the second, third, and fourth metatarsals these bones were also externally rotated."

Dislocations of the Phalanges.—The toes are not uncommonly dislocated by blows upon their tips. Metatarsal phalangeal dislocation of the great toe may be caused by a fall upon the toe, by kicking, etc. According to Stimson,[146] "If the lateral displacement is wide, the flexor tendon may slip past the head of the metatarsal bone and make reduction impossible except by operation," Such an operation is best accomplished with the patient under general anesthesia and, of course, with strict attention to asepsis. Tenotomy of the extensor tendon or skidding it into place may be done. After tenotomy and

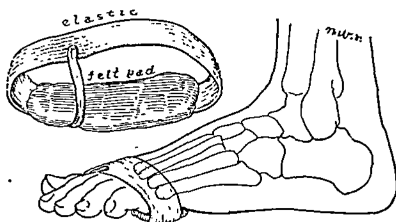


Fig 448.—Adjustable metatarsal pad. (Milch, H.: Am. J. Surg. 3: 594, 1927.)

after reduction of the dislocation, the severed tendon may be united by suture. Of the phalangeal dislocations, that of the terminal phalanx of the great toe is the commonest. The dislocations are readily reduced by hyperextension and traction, generally without anesthesia. *x*-Ray examination must never be omitted, because of the likelihood of coincidental fracture.

Epiphysial Separations of the Lower Extremity.—*Displacement of the Upper Femoral Epiphysis.*—This condition is found in children 11 to 16 years of age. Trauma is a factor in the etiology. There is pain in the hip or referred pain to the knee. The thigh is held in adduction and external rotation. Abduction may be limited. The *x*-ray findings are characteristic. According to Brogden,[147] 67 per cent of patients treated by the Whitman abduction spica have good end-results. This method should be used in cases of less than four months' duration. Pomeranz and Sloane[148] say: "Very early cases in most instances heal best by immobilization or rest without manipulation." Certain of their patients were treated by the Cotton impaction method or by drilling. Wilson[149] advises insertion of a Smith-Petersen flanged nail in cases of slipping of the upper femoral epiphysis with minimal displacement.[150]

Epiphysial Separation of the Lesser Femoral Trochanter.—According to Lapidus,[151] this "is a comparatively rare condition, usually seen in children, mostly boys, between the ages of thirteen and seventeen" (Fig. 449). In these cases pain and tenderness are felt over the lesser femoral trochanter, and the patient is not able "to raise the thigh actively from the sitting position though there is some active flexion of the thigh in the recumbent position" (Ludloff's sign). Noteworthy is "the gait of deficient flexion of the thigh." (Lapidus) Recovery occurs in from four to eight weeks. The treatment varies from rest in bed to immobilization in plaster of paris, depending upon the severity of the separation.

King[152] prefers three weeks of immobilization of the thigh in flexion, preferably in a plaster cast. He says that in 92 per cent of a series of 50 cases reported in the literature there was perfect healing with no loss of function, although a wide variety of methods of treatment was used.



Fig. 449.—Epiphysial separation of the lesser femoral trochanter. (Lapidus, P. W.: J Bone & Joint Surg. 12: 548, 1930.)

Separation of the Lower Femoral Epiphysis.—Traumatic separation of the lower femoral epiphysis is rare. Bilateral separation has been reported.[153] Reduction is usually easy.[154]

Separation of the Epiphysis of the Great Trochanter.—A case is reported by Milch.[155]

Minor Fractures of the Lower Extremity.—*Femur.*—(*a*) *Impacted Fracture of the Neck of the Femur.*—Impacted fractures of the neck of the femur occur most commonly in the aged, usually caused by a fall on the great trochanter. Hart[156] has supplied a definition of impacted fracture of the neck of the femur in the following words:

"Clinically, the fractured extremity can be moved freely and almost painlessly. The patient may even walk after the injury. The severe pain, muscle spasm, external rotation [illegible] the limb which character- [illegible] it. Radiologically, the frac- [illegible] orizontal, and the neck and

shaft of the femur are abducted in relation to the head. The normal angle of head, neck, and shaft is increased and a coxa valga deformity is present. The lateral radiogram shows no displacement between the head and neck fragments. These radiographic findings are essential in the diagnosis of "impacted fracture." The fracture is impacted because the mechanical forces between the two fragments are pressure forces and not shearing forces. There is never a true impaction if the normal angle between the two fragments is diminished with a coxa vara deformity because the forces between the fragments are then shearing and not pressure forces."

The cardinal principle in the treatment of this condition is the avoidance of the breaking up of the impaction. Violent manipulations, of course, are contraindicated. The usual treatment has been rest in bed for about six weeks. I have obtained 100 per cent success, however, in my 8 or 9 cases by the application of a short abduction spica, elevation of the opposite heel about 2 inches and early weight bearing. Walking with crutches is started on the second or third day, and the crutches are discarded by the seventh to the tenth day. The spica cast is removed at six weeks and the elevated heel at four to six months. Cases of coxa valga are most suitable for this treatment.[157]

(*b*) *Linear Fractures of the Neck of the Femur.*—Linear fractures or fissures of the neck of the femur may occur in adolescents. They may be easily overlooked without a careful inspection of the roentgenogram. The treatment is simple rest in bed for three to five weeks.

(*c*) *Fracture of the Great Trochanter of the Femur.*—This injury usually results from excessive pull of the external rotator muscles of the thigh. According to Milch,[158] who reported 6 cases: "Elevation of the trochanter in the absence of any change in length of the leg is pathognomonic of the condition. Immobilization is the treatment of choice, even though satisfactory results have been obtained even in cases in which expectant treatment was used. Only in cases in which wide separation of the fragments has occurred are open operation and suture of bone indicated."

(*d*) *Fracture of the Lesser Trochanter of the Femur.*—This fracture generally occurs in young persons as a result of a powerful contraction of the psoas muscle, which attaches to the lesser trochanter. The patient may remember a sudden painful snap while running. The pain is localized to the upper inner aspect of the thigh and is accentuated when he tries to stand erect or to flex the thighs, both of which motions put a stretch on the attachment of the psoas muscle. Walking may be possible but painful. There may be pain referred to the knee region and inability to cross the legs. The treatment of choice is that recommended by Speed.[159] This consists in placing the patient in a sitting position in bed, the limb being supported in an upright or slightly inverted position by sand bags. Three or four weeks are required to eliminate the symptoms; the amount of time is gauged by the amount of pain when the leg is actively extended. To relieve the sitting posture, the patient may lie supine with the thigh flexed on the trunk held by pillows or splints.[160]

(*e*) *Fractures of the Shaft of the Femur in Infants and Young Children.*—Fractures of the shaft of the femur in very young children and even in those up to 8 years of age are so easily and so successfully treated by the simple expedient of overhead traction that this condition is properly considered a minor surgical ailment (Figs. 450, 451). A certain amount of skill and care is requisite to the proper application of the overhead traction. Two pieces of moleskin adhesive plaster are prepared so that they are long enough to

reach from the groin to a point 12 inches distal from the foot. An assistant holds the extremity suspended by the foot, while the moleskin is smoothly and carefully applied to the lateral surface of the leg. The plaster should be a

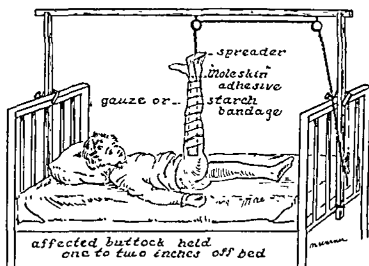


Fig. 450.—Treatment of fracture of the femur in a child by overhead suspension. Fixed suspension is preferable to counterbalanced weights.

little wider near the proximal end of the extremity than at the distal end. To avoid wrinkling, it may be necessary to make small darts or incisions at the borders of the plaster in the region of the knee joint and the ankle. The



Fig. 451.—Suspension treatment of fracture of the femur in an infant.

adhesive plaster is held in place by spiral strips of adhesive plaster and bya snug but very smoothly applied gauze bandage. Because of the elasticity of the soft parts of the thigh, the proximal end of the adhesive may be 2 or 3 inches proximal to the upper end of the fracture. The lower ends of the

moleskin adhesive plaster are now folded over upon themselves so as to form a strap. These strap ends are wound over a wooden spreader and made fast by thumb tacks and by encircling bands of adhesive tape. It is extremely important that the spreader be of sufficient width, so that the lower ends of the moleskin adhesive plaster will not press upon the malleoli at the ankle, as pressure sores may result. It is also extremely important that the lower turns of bandage are not pressed too tightly upon the skin over the tendo achillis, as pressure sores may result. Selig[161] advises the avoidance of adhesive strip pressure over the upper 3 inches of the fibula because of the danger of compressing the peroneal nerve against the fibula. He reports five cases of pressure neuritis. A strong rope is now passed through the hole through the center of the spreader and knotted so that it will not slip through the hole when traction is made upon it. Strong cord may be used, in which event it is looped over a tongue depressor cross piece under the spreader (Fig. 452). The distal rope is then passed through a pulley which has been suspended from an overhead Balkan frame. The rope is then carried to a second pulley at the foot of the bed and is made fast to a cleat at the upright of the Balkan

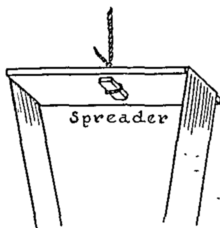


Fig. 452.—Type of spreader used in suspension of the leg.

frame. The author prefers fixed traction in the case of young children to traction by counterbalancing weights. Sufficient traction is put upon this rope so that the child's buttock is at least 1½ inches above the bed. This arrangement greatly facilitates the nursing care. Urination and defecation can be taken care of without disturbing the child's comfort. The nurse, however, *must be warned* not to lift up the buttocks by placing her hand under them, under any circumstances, such as in the placing of a bed pan. This procedure not only would cause the child great pain but would disturb the alignment of the fragments. Should any elevation of the buttocks be required for any reason, it should be accomplished by lifting the overhead traction. In the case of strong muscled children under 8 years and all those over 8 years, David[162] lowers the leg and uses overhead traction with the leg flexion, external rotation and abduction. After about twenty-four to thirty-six hours the muscles of the thigh become relaxed, and the fragments of the femur will come into excellent position. By means of a portable *x*-ray machine, the reduction of the fracture should be checked from time to time. Should more traction be required, the extremity on the affected side may be pulled still

higher. In very young infants it is advantageous to suspend both legs, but if greater traction is required, it will be necessary to suspend one leg only. The extremity is kept in overhead traction for a period of six weeks on an average. At the end of this time, after the repair has been checked as well as possible by *x*-ray (Fig. 453), the leg is lowered carefully to the bed. After a few days of skillful massage and active motion at the knee joint the patient is equipped with a Thomas walking caliper splint.

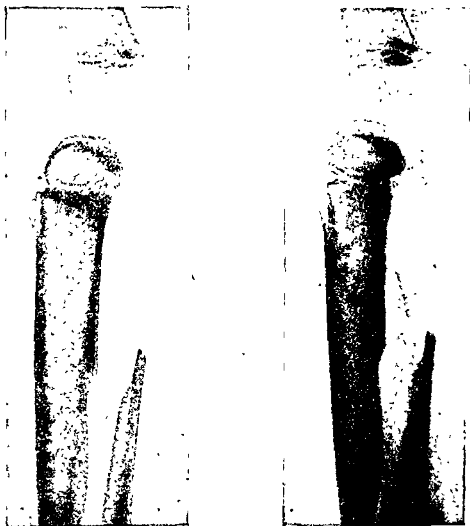


Fig 453.—*A*, Fracture of the femur in a child. *B*, Same fracture, showing the manner in which callus can bridge over the defect.

Young[163] has given some very valuable suggestions in regard to fitting the ring of a Thomas splint. In fitting the ring of an ambulatory caliper, Young says: "In the ambulatory caliper the problem of fitting the Thomas ring is much greater. Here the tuber ischii must rest on the ring to transmit the body weight to the side bars of the brace. There is a tendency of the ring to slip medially into the groin so that it presses upward on the perineum and the ischiorectal fossa. The problem is increased directly in proportion to the amount of subcutaneous adipose tissue. A ring with an oval or circular circumference as ordinarily used does not fit inferior to the tuber ischii.

"After experimenting with rings of various sizes and shapes, it has been found that an irregular oval is the only efficient ring for this purpose. The small end of the oval is medial. Only the posterior two-thirds of the thigh is fitted with the padded metal oval, a wide

leather cuff completing the anterior third. The measurement for the internal circumference of the metal and padding should be two-thirds the circumference of the thigh at the groin.

"The medioposterior segment of the oval opposite the tuber ischii should have its curve reversed, so that its convexity projects laterally to make a shelf on which the tuber ischii can rest. This lessens the capacity of the ring, so that the subcutaneous fat overlying the tuber ischii must be displaced by pressure. Some allowance in the measurement and fitting must be made according to the amount of subcutaneous fat in each patient. The ring here as in the recumbent use should be lower medially at an angle of 110 degrees with the medial side bar. The anterior leather cuff should be from 4 to 8 inches long. This will distribute the pressure sufficiently over the anterior thigh to prevent circulatory disturbance. This cuff is buckled with firm tension to hold the thigh posterior so that the tuber ischii will not slip forward. The diameter of the rim of the padded metal posterior two-thirds of the ring should not be larger than 2.5 cm. in adults and correspondingly smaller in children.

"In the actual manufacture of the caliper, the bracemaker begins his diagram by drawing a circle to correspond to the size of the circumference of the thigh at the groin. A larger circle is drawn concentrically for the external circumference of the padded ring. These [illegible]

The walking caliper is worn in the daytime for six to eight weeks. After about the fourth week the adjustment of the caliper is changed every week so as to permit a slightly increasing amount of weight upon the fracture.

David studied 75 cases of fractured femurs in children at the Cook County Hospital, Chicago, and found that when the fractured femur united with shortening, compensatory overgrowth took place. As time went on, the injured and shortened leg became longer, and limping gradually ceased. Alignment of the fragments is more important than end to end apposition. When the latter is not obtained, late roentgenograms show practically normal restitution of the shaft.

Conwell[164] made a very interesting study of fractures of the femur in children, and all who are interested in this subject are referred to his article. He reported 86 cases and reviewed all the ordinary methods of treatment. He says: "A summary of the cases treated by suspension and extension shows that better results are obtained in all ages up to the age of ten and eleven years than in either the series treated by plaster cast or in the series treated by plaster cast and extension.

"The suspension and extension method is by far the most comfortable dressing, and best results have been obtained by this method. This method facilitates frequent daily examinations, frequent checks with x-ray, dressings in compound wounds; makes easy the application of radiant light, hot baths, and active and passive motion. All of these make for a shorter convalescence and better functional results" (Fig. 454). [illegible]

(*f*) *Minor Fractures of the Condyle and Epicondyle of the Femur.*—Fractures of the internal epicondyle of the femur, to which the adductor muscle and the internal head of the gastrocnemius muscle are attached, are of fairly common occurrence. The diagnosis is based on the localized tenderness and the x-ray evidence. In the cases of slight fractures, in which a small fragment of bone is detached, the treatment will consist of rest in bed for ten days with a molded plaster of paris splint or a cast, followed by restriction of exercise for a few weeks. Adhesive plaster strapping will effect a cure in some

cases. Penhallow[166] has described an intracondylar or transcondylar linear fracture of the femur, which is simply treated by fixation in plaster with the leg in slight flexion.

(*g*) *Birth Fractures of the Femur.*—Birth fractures of the femur (Fig. 455) are best treated by means of overhead traction. Either moleskin or adhesive plaster is carefully applied to one or both legs, depending upon the type of fracture and the amount of traction required (Fig. 456). When a greater amount of traction is required but one extremity is suspended. The extremity or extremities are suspended vertically so that the buttocks do not touch the bed. (See the section on Fractures of the Femur.) The use of the plaster cast in a newborn babe is extremely dangerous because of the almost certain



Fig. 454.—Apparatus for suspension in fracture of the femur. (Conwell, H. E.: J. Bone & Joint Surg. 11: 593, 1929.)

soiling of the cast with urine and feces and the consequent danger to the skin. The device of Gordon[167] has the additional merit that the infant can be moved easily so that breast nursing is not interfered with. Gordon says: "The principles involved are the old Bradford frame half covered to support the body; an upright extension to maintain suspension support for the legs; a *binder*, a leaf of which goes about the body of the infant, another leaf which is laced to the frame and holds the body to the covered part of the frame.

"The frame is preferably made of the 6-foot Bessemer steel rodding found in hardware stores, or round bar iron of a diameter best suited to the weight and size of the child. Quarter inch to 5/16 inch suitable for the base, the same for the uprights, and 3/16 inch for the piece which acts as a means of



Fig. 455.—Birth fracture of the femur.

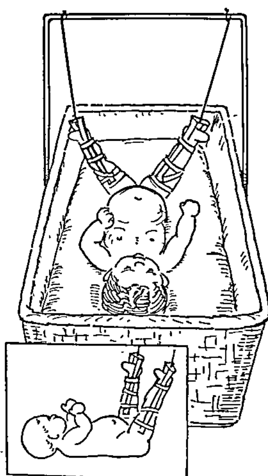
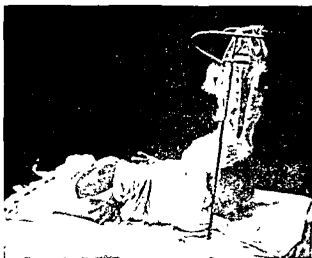


Fig. 456.—Treatment of birth fractures of the femur. The buttocks are lifted just off the bed.

keeping the blanket off the feet. The different parts can be wired and soldered, or the copper wire covered with adhesive plaster to make a firmer joint and prevent the twisted end of the wire from scratching. The height of the support for the legs (Fig. 457) should be long enough to allow 3 to 4 inches above the soles of the feet with the buttocks raised up above the base of the frame."

Fractures in the newborn heal with extreme rapidity, and immobilization for two or three weeks will be all that is required in most cases. The formation



a



b

Fig. 457.—*a*, Infant with fracture of femur with frame adjusted; *b*, infant in frame wrapped up and asleep. (Gordon, D : Am. J. Surg. 6: 768, 1929.)

of callus is abundant. Discrepancies of reduction are quickly overcome by the rapid growth of the bone.

White[168] reports an instructive case in this regard. A birth fracture of the femur was treated by overhead traction but abandoned because of skin irritation. When first seen by White (Fig. 458) there was considerable callus and firm fixation. The parents pressed for immediate operation, but White

counselled no treatment at all. *Nine weeks* later the injured leg could not be recognized grossly, and its length was the same as that of the opposite leg (Fig. 459). *Birth fractures of the tibia* are treated by applying a plaster cast, extending from the toes to the groin with the knee flexed, which is removed after four or five weeks.[169]



Fig 458 —Condition when patient was first seen, at age of 3 weeks.

Patella.—Chipping fractures of the patella or complete transverse fractures of the patella without separation, or with slight separation of the fragments in elderly persons or those leading a sedentary life, and longitudinal fractures[170] belong to the domain of minor surgery. The diagnosis is based on the history of a fall on the patella or of sudden pain in the knee following

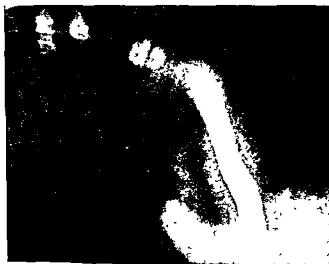


Fig. 459.—Lateral view of fracture shown in preceding figure taken nine weeks later. (White, R. J.: Ann. Surg. 97: 639, 1933.)

violent exercise (forcible contraction of the quadriceps femoris), the localized pain and tenderness and the *x*-ray picture. Treatment must be early, with elevation, icebags, rest and pressure elastic bandages. Meekison[171] reports 3 cases of fracture of the inferior mesial corner of the articular surface of the patella. He recommends treatment by excision.

Scudder[172] says that sponge compresses may be used. "Two slightly moistened bath [illegible] lation of fluid and favoring its absorption. These wet sponge compresses should be left in position for from twelve to twenty-four hours, and then a fresh set used."

Aspiration of the knee joint under strict aseptic conditions will accelerate removal of the effusion. The treatment is immobilization in a plaster cast for four weeks. A window should be cut in the cast over the site of the injury at the end of the first week. Through this window, which should be of ample size, gentle massage is carried out to improve the local circulation and to

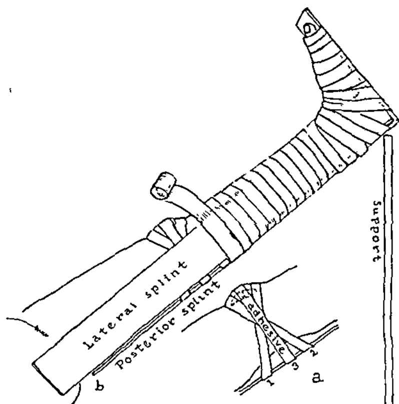


Fig. 460.—Nonoperative treatment of fracture of the patella. *a*, Method of strapping patellar fragments. *b*, Application of splint. (After Scudder.)

deter adhesions from forming between the patella and the underlying femur. At the end of this time the cast is cut in half, and daily heat, massage and motion of the knee joint are instituted. The cast is replaced after these treatments and is worn for another two to four weeks, the patient getting around on crutches. Complete return of function may be expected in four to six months. Walking may be permitted in the case of a chipping fracture as soon as the cast is applied. In the complete fractures without separation, walking should be prohibited for three or four weeks.

When there is marked separation of the fragments with no contraindication, such as diabetes which has not been appropriately treated, advanced tuberculosis, cardiac and renal affection, or old age, open operation is the best treatment.[173] When, however, the conditions are not suitable for the carrying

out of an open operation, a serviceable knee will be obtained in over half the cases by nonoperative means. The leg is put at rest and elevated. Absorption of the effusion in the vicinity of the knee joint should be encouraged by cold and hot applications and by massage. When nearly all of the fluid has been [illegible]
[illegible]
plane to relax the quadriceps femoris muscle. Adhesive plaster straps are then obliquely crossed about the fragments so as to secure, as nearly as possible, their approximation (Fig. 460). Scudder advises a third strap immediately over the broken edges of the fragments to hold them in apposition. This fixation is maintained for four to six weeks. The leg is fixed, on walking, for some six months, by a brace or plaster cast. A cane and snug knee bandage may be used for a month or two longer. Gatewood[174] presents a closed method of reduction of fracture of the patella (Fig. 461).

Lapidus[175] has studied longitudinal fractures of the patella. He says the lesion is not uncommon and requires a special type of roentgen study of both knees for its recognition. In regard to treatment, he says:

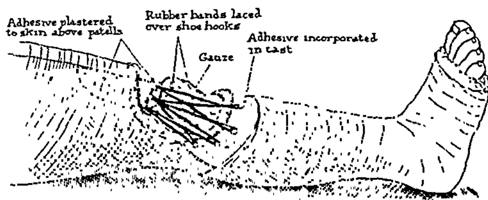


Fig. 461.—Method of dressing the infected prepatellar region and maintaining apposition of separated fragments of the patella at same time. (Gatewood: Am. J. Surg. 21: 28, 1932.)

"Immediate aspiration of the knee joint with immobilization during the *first three* to five days by means of a posterior molded plaster-of-paris splint, with elevated position of the limb, should be recommended in order to *minimize* the amount of post-traumatic reaction. After that, the patient may be allowed to walk with a strapping of his knee, avoiding the overuse of his lower extremity."

Lapidus "believes that immediate aspiration of the knee joint and repeated reaspirations every two to three days, until there is no evidence of [illegible] articular effusion, is of great [illegible] of repeated aspirations of th[illegible]

Tibia.—(*a*) *Incomplete fracture of the shaft of the tibia* is, at any age, amenable to minor surgical measures. The leg is placed upon a pillow or upon sand bags. Ice bags, with due precaution not to have them rest directly against the skin but to have a towel interposed, are placed about the affected area until the maximum swelling has been reached and has started to subside. According to Roberts and Vogt:[176] "*Pseudofracture of the tibia* is a clinical entity involving the upper third of the tibial shaft in children between the ages of four and sixteen. At one stage of the disease the roentgenographic appearance may simulate a fracture, but acute trauma, nevertheless, is not

an etiological factor." The exact nature of this condition is not known. It may be similar to march fracture. Tabb and Packer,[177] in reporting two cases, recommend bed rest during the acute phase and a splint or plaster cast for eight to twelve weeks. In many cases of fissures and linear fractures of the tibia the swelling will be so small that it will be possible to apply a cast at once. The small amount of sheet wadding inside the cast and the elevation of the extremity on a pillow will take care of any slight swelling which may occur. At this time a circular plaster cast is applied from the tip of the toes to the groin. (Pressure on prominences and too great extension in the cast must be avoided.) The method of applying this cast has been described previously. Care should be taken not to permit the cast to exert pressure upon the tip of the fifth metatarsal (Lisfranc's tubercle), because

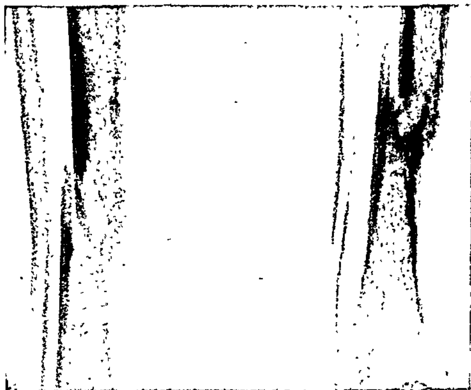


Fig. 462.—Fracture of the tibia showing manner of bridging of the defect by callus

of the resultant pain and the likelihood of pressure sores. The leg will be kept in a cast for six weeks, during the latter part of which walking on crutches, but not weight bearing, will be permitted. After removal of the cast, massage and active and passive motion will be instituted. The patient will still use the crutches but will gradually bear an increasing amount of weight on the foot.

(*b*) *Complete Fractures of the Tibia with an Intact Periosteum.*—In these cases no reduction will be required other than the securing of the proper alignment, which is readily obtained by supporting the leg and exerting upon it a slight amount of traction. The treatment otherwise will be as outlined in the preceding paragraph. A warning should be made as to the likelihood of "dishing" of the fracture, when the leg is supported during the application of the plaster cast. This fault may be avoided by a moderate amount of supporting pressure on the fracture itself. A word of warning

must be made regarding this latter maneuver: Sharp pressure should not be made upon the wet plaster of paris, because when it dries, there will be painful projections on the inside of the cast.[178]

Fractures of the condyles of the tibia cannot be taken up in this volume. For those interested, reference should be made to various articles.[179]

(*c*) *Fractures of Both Bones of the Leg.*—Many fractures involving both bones of the leg present major surgical problems. Reduction may be very difficult; in fact, it may be obtained in some cases only by skeletal traction applied through the os calcis or through the lower ends of the tibia and fibula or by traction with a Sinclair skate. Many other fractures are cared for simply by the application of a circular nonpadded or lightly padded cast from the groin to the toes while traction is exerted upon the extremity. It is important to avoid posterior sagging of the bones while the cast is applied. It may be necessary to hold the foot in plantar flexion to obtain good alignment of the



Fig. 463.—Fracture of the internal malleolus.

shafts of the tibia and fibula. Fractures of the lower third of the tibia are notoriously slow in healing. Cautious weight bearing in a well fitting cast will be a stimulus to callus formation.[180]

(*d*) *Isolated Fractures of the Internal Malleolus.*—The occurrence of isolated fractures of the internal malleolus is unusual without coincident fracture of the external malleolus (Fig. 463). In 100 cases of fracture of the ankle studied by MacKinnon[181] only 7 cases involving the internal malleolus alone were found. In cases of fracture of the internal malleolus the astragalus generally is dislocated mesially. This condition is treated by the application of "sugar tongs" and posterior molded plaster of paris splints after the maximum swelling has been reached and has started to subside. The foot is placed in a position of dorsal flexion and *eversion.* After seven to ten days the splint may be removed and replaced three to five times weekly. While it is off, gentle active motion, hot foot baths and gentle massage are prescribed. Careful weight bearing will be started on or about the twenty-first day.

(*e*) *Fractures of the Tibial Epiphysis.*—While rare in the United States, these fractures are relatively common in Great Britain. McFarland[182] attributes this difference to the fact that there are many more vertical rod fences to enclose gardens in the latter country and that the children frequently catch a foot between the rods. The results of this accident are serious. There is a traumatic arrest of epiphysial growth at the lower end of the tibia with an angular deformity of the ankle joint. It would seem that this deformity *might* be prevented if, at the time of the acute injury, weight bearing were prohibited and the ankle immobilized for a few weeks.

(*f*) *Fracture of the Tibial Tubercle.*—This uncommon injury is not to be confused with Osgood-Schlatter's disease. Raymond[183] reports a case of this injury caused by avulsion while high jumping by a boy of 15. Open reduction was used.

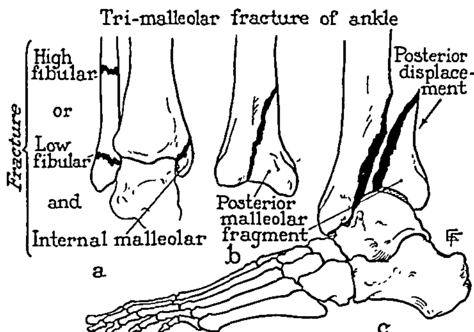


Fig. 464.—Trimalleolar fracture of the ankle. (Henderson, M. S., and Stuck, W. G : J. Bone & Joint Surg. 15. 882, 1933.)

(*g*) *Fractures of the Posterior Malleolus; Posterior Articular Margin of the Tibia.* (See also Fractures of the Fibula and Ankle Fractures.)—This fracture probably rarely occurs by itself, but rather as an accompaniment of fractures of the external malleolus and, less commonly, of the internal malleolus. In MacKinnon's study of 100 ankle fractures there were 10 fractures of the posterior articular margin of the tibia. According to the author, the mechanism causing fracture of the posterior lip is usually a fall with the foot doubled under the body. The fragment is generally dislocated upward, and there is a posterior dislocation of the astragalus upon the lower end of the tibia. Reduction is generally done under complete general anesthesia, but local anesthesia has been found to be very satisfactory in many hands. Because of the pull of the tendo achillis, there is a great tendency for the dislocation to recur after reduction. Reduction may sometimes be maintained by placing the foot in dorsal flexion and applying a cast. If the fragment is large, how-



Fig. 465.—Severe Pott's fracture. Fracture of both internal and external malleoli. Note the posterior dislocation of the astragalus in the lateral view.

ever, this procedure may cause posterior dislocation of the astragalus. In this event reduction may be obtained by placing the foot in plantar flexion. In all cases several x-ray examinations must be made in the first few weeks, as the fragments have been known to become displaced inside the cast.

As pointed out by Henderson,[184] the success of the reduction depends *upon the size of the posterior malleolar fragment. If the fragment is large* (Fig. 464) it may be necessary to do an open operation and fasten it in place by some form of internal fixation or cut the tendon of Achilles as described elsewhere. If the fragment is small it will stay in place after reduction. The *author has seen some severe fractures of this type* (Fig. 465) but has not as yet had to resort to any procedure except manipulation and application of a cast. An ankle fracture should be reduced immediately and immobilized in plaster of paris for four to eight weeks before physiotherapy is begun.[185]

(*h*) *Paratrooper Fracture.*—This term is applied by Tobin[186] to a fracture of the posterior articular margin of the tibia, an injury which was found in 12 per cent of the total of 272 fractures occurring at a paratrooper training

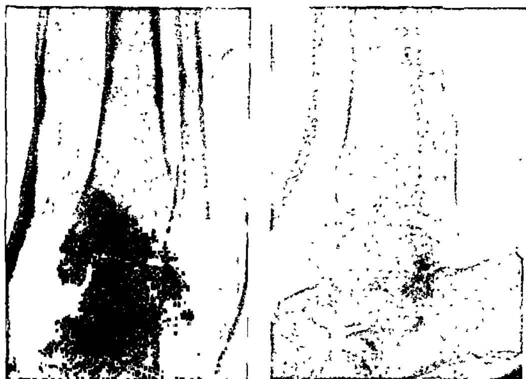


Fig. 466.—Anteroposterior and lateral views of the fracture shown in the preceding figure after reduction and incorporation in a plaster cast

field. The external malleolus was fractured in 23 per cent of the cases. The "paratrooper fracture" was immobilized in a skintight cast with walking iron for four weeks. Parachute jumping was permitted after three months.[187] Lord and Coutts,[188] in a study of over 250,000 parachute descents, say that in one descent the parachutist has 1 per cent chance of injury. They noted the following typical injuries: (*a*) strain of the right rectus muscle, (*b*) contusions and separations of the acromioclavicular joint, (*c*) fracture of the lower third of the fibula, associated with fracture of the posterior tibial lip and (*d*) "silent fracture" of the upper third of the fibula. Holding the feet together on contact with the ground reduced the number of ankle fractures. In 129 parachute-jump fractures, Knepper[189] found the incidence to be as follows: skull, 6; nose, 4; maxilla, 2; humerus, 5; radius, 4; navicular (carpal), 3; metacarpals, 6; phalanx, 7; rib, 4; compression of vertebrae, 7;

sacrum, 1; coccyx, 1; femur, 1; patella, 2; tibia, 22; trimalleolar, 6; fibula, distal portion, 29; astragalus, 1; os calcis, 3; cuboid, 2; tarsal, 2; metatarsal, 7; toes, 4.

Fibula.—(a) Pott's Fracture (Ankle Fractures).—Fractures of the lower end of the fibula, the external malleolus, are extremely common and occur as the result of violent wrenches of the ankle, particularly those causing eversion. The diagnosis is readily suspected by the history of the traumatism, pain and swelling about the ankle joint, by the localized tenderness on the lower surface of the fibula and by *x*-ray examination (Figs. 465, 466). The point of local tenderness is on the side of the fibula at varying distances above the distal end and in contradistinction to the points of tenderness in sprained ankle, which are below or lateral to the tip of the fibula, or else directly on the tip of the fibula.

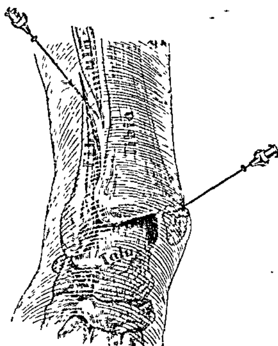


Fig 467.—Injection of local anesthetic in a fracture of the ankle. (Rice, C. O : Surg., Gynec. & Obst. 52: 887, 1931)

Fracture of the lower end of the fibula is so often accompanied by fracture of the internal or posterior malleolus and by rupture of the tibiofibular ligament that the term *ankle fracture* is probably preferable to Pott's fracture. Henderson[190] carefully analyzed 1266 reported cases and found fracture of the external malleolus alone in 34 per cent, fracture of both malleoli in 35.2 per cent, fracture of the internal malleolus alone in 10.1 per cent, and fracture of the posterior malleolus with or without other injuries in 9.6 per cent. In *trimalleolar fractures* all three malleoli are broken (Fig. 464).[191] Nelson and Jensen[192] believe that "classical" trimalleolar fractures are "best treated by very early open operation followed by manipulation."

When there is displacement of the fragments, reduction should be effected immediately. With regard to fractures in and about the ankle joint, it has been stated that reduction is usually quite easy if undertaken in the first few hours after the fracture occurs. A skillfully administered gas anesthetic is the

most suitable and convenient. A very satisfactory anesthetic is from 10 to 15 cc. of a 2 per cent solution of procain hydrochloride injected into the hematoma about the fracture (Fig. 467). It is most important to secure the normal relationship of the articulating surfaces of the ankle joint. General anesthesia is usually preferable if proper facilities for its administration are at hand. Pentothal intravenous anesthesia will be useful if properly managed.

After reduction, the ankle may be immobilized in "sugar tongs" and a posterior molded plaster of paris splint. A cast is less satisfactory because it cannot be as readily adjusted to changes in size when swelling increases or diminishes. In trimalleolar fractures the knee is flexed and the cast may be brought above the knee. The usual cast will end below the knee so as to permit flexion at that joint. If possible the foot is held in dorsal flexion and inversion. If there is not dorsal flexion, there will be a temporary shortening of the tendo achillis and delay in recovery. The position of inversion is of extreme importance. A fracture of the external malleolus causes a widening of the mortise of the ankle joint with lateral subluxation of the astragalus. When the foot is placed in a position of inversion, the fractured tip of the fibula is brought inward, and the mortise is narrowed to its original width. In cases in which this precaution is not taken, there will be a demonstrable side slip of the foot on the leg, and the period of disability will be definitely increased.

The author has come to prefer *molded splints* to the circular cast for ankle fractures. For this purpose the "sugar tongs" and posterior splints are desirable. Jewett[193] describes the preparation of these splints as follows:

"These splints are made in the usual manner of either 3 inch or 5 inch wide plaster-of-Paris bandage. It is better to use the plain dental plaster with nothing added to it, which results in a setting time of from four to five minutes. The average thickness of the splint is six to eight layers, but at times as many as twelve will be necessary. A strip of Canton flannel, somewhat wider than the splint, is placed on the skin side of the plaster with the free edges turned over onto the back. This makes a neat, smooth-edged splint, and is generally the only padding that is used. Careful moulding of the splint to the underlying limb is very important, as inexact application gives rise to pressure and discomfort later on. The gauze bandage first applied to hold the splints in place as they harden is usually best replaced before the patient goes home or into a hospital bed by one a little looser, more carefully applied. Spirally wound adhesive tape is obviously best applied after the post-reduction x-ray plates have been taken." (Fig. 468.)

Jewett adds: "Frequently this type of splint can be used in place of a circular cast with equal immobilization certainty; that is, barring unusual accidents to the limbs. One of the [illegible] post-
[illegible] who
[illegible] sent
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toes and [illegible] degree of
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office, the bandage can be removed easily, and a looser one applied very much easier than a cast can be bivalved. A cast that is bivalved immediately after application is about as [illegible] of the encased limb
[illegible] itage of the splint
[illegible] the limb must be
[illegible] amount of plaster
[illegible] is plaster."

After the splint is applied the patient is placed in bed and the extremity elevated 20 to 30 degrees. He is encouraged to move the toes frequently. These measures will improve the circulation and reduce swelling.[194]

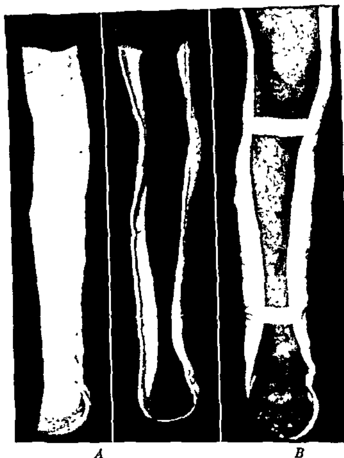


Fig. 468.—*A*, Posterior and U splint for leg; *B*, posterior and U splint for leg applied. (Jewett, E. L.: Am. J. Surg. 26: 336, 1934.)



Fig. 469 —Result of the application of a tight circular cast for five days in a case of ankle fracture.

The patient is gotten up on crutches after a few days. The toes are carefully observed for color, temperature and swelling. If there are marked signs of obstructed circulation, the foot is elevated, and if this fails, the splint must

be loosened promptly. If a cast has been used, it must be bivalved at the first sign of undue swelling within it.

After ten to fourteen days the splint is removed and replaced in order to permit increasing careful active motion, skilled massage and daily or twice daily hot soakings or bakings with hot lamps (infra-red is very useful). After about three weeks, weight bearing is gradually instituted.

Krida[195] gives the following treatment for Pott's fracture: "(1) If there is displacement requiring reduction, this is done and a short period of rest is allowed. (2) In fractures with no displacement, two or three days' rest in a sheet-wadding bandage compression dressing. (3) Following this, adhesive . . . is applied with the foot in dorsal flexion and adduction. . . . The base of the dressing is two 2-inch strips which begin on the outer side of the leg, passing downward across the os calcis, abducting that bone, and then upward on the inner side of the leg to the upper border of the calf. Over this are applied successive 2-inch strips, encircling the limb from the base of the toes to the upper border of the calf, but leaving a small segment of the heel uncovered. The patient is then instructed to begin systematic movements at the ankle-joint. In order to be assured that he uses his tibialis anticus muscle for dorsal flexion movements, he is instructed to keep his toes plantar flexed. The dressings sufficiently fix the fragments so that no discomfort accompanies the exercise. Weight bearing and walking in a shoe, the heel of which has been raised ¼ inch on the inner side, is encouraged three to six days after the injury. (4) The adhesive dressing is renewed every four or five days. The surgeon must be satisfied that the exercises and movements are being properly carried out. (5) This régime of dressing is carried out for six weeks. Union is then sufficiently advanced so that no deformity will result. The raised heel is maintained, exercises and proper weight bearing are encouraged until mobility is restored."

Conwell,[196] in his study of fractures of the ankle, has given the following valuable suggestions:

"Too early motion in some cases of injury to the ankle joint is not to be desired. Fixation in a plaster cast over a considerable period of time to aid repair of the soft structures and to prevent instability of the joint is very important.

"Complete ankylosis in certain cases is to be desired more than a painful and unstable ankle joint.

"The circulation should be watched at all times, especially in the simple fracture-dislocation where extensive subcutaneous and intramuscular hemorrhage takes place causing severe pressure.

"To prevent any possible rotation of the tibia and fibula at the ankle, the plaster cast must extend from the base of the toes to the middle of the thigh. The foot should usually be placed at right angles to leg, *midway between adduction and abduction, with 20 to 30* degrees of flexion at the knee joint.

"No weight bearing should be carried out before two months in any fracture-dislocation of the ankle, and an orthopedic heel with proper elevation to inner half as well as felt pad to instep of the shoe should always be applied."

In many ankle joint fractures, after the cast is dry and the *x*-ray examination shows the position to be satisfactory, some surgeons incorporate a *walking iron* in the cast and carry out an ambulatory method of treatment after the method of Bohler. This iron is described by Perkins and Mulhern[197] as follows: "The iron heel consists of an iron bar 26 inches long, ⅛ inch thick, and ¾ inch wide, to which are riveted at both ends two cross pieces, each 5 inches long, ¼ inch wide and 1⁄16 inch thick. This bar when ready to use is bent in a U-shaped manner (Fig. 470) and is applied to the contour of the cast in the axis of the leg in such a manner that it extends 1 inch below the plantar surface of the cast. The cross

[illegible]

...ow ready to be discharged to out-
... "lack of atrophy of the tissues and
... member" on removal of the cast.

(See also Fig. 472.)

Forrester[198] applies his walking iron immediately but does not permit efforts at weight

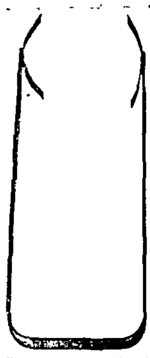


Fig. 470.—Walking iron.



Fig. 471.—Walking iron incorporated in a cast. (Perkins, R. S., and Mulhern, J. P.: J. Bone & Joint Surg. 13: 138, 1931.)

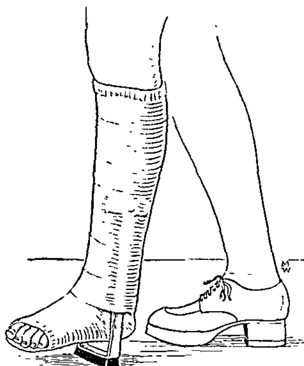


Fig. 472.—Plaster cast with caliper attached. Note raising of the shoe on the opposite foot to simplify walking. (From Hauser, E. D. W.: Diseases of the Foot, Philadelphia, W. B. Saunders Co, 1939.)

bearing for seventy-two hours. He points out that the cast and iron should be so arranged that the weight bearing is taken on the knee joint "as in the bucket of an artificial limb."

Lorenzetti[199] treats ankle fractures by bandaging to a wooden splint so that the foot

injury may require major surgical treatment. However, when the os calcis has been compressed so that its lateral surfaces bulge outward, the treatment will be minor surgical. The foot is placed upon a hard object and the lateral surface of the os calcis is struck a sharp blow with a padded mallet or hammer. Or an attempt may be made to narrow the fractured mass of the os calcis by the use of padded metal calipers which squeeze the separated bone together.[210] Goff[211] has obtained good results by compression with a carpenter's clamp with rounded wooden blocks attached to the jaws. By either method the unnatural convexity of the fractured os calcis may be corrected. Immobilization in a plaster cast will be required for a period of six weeks. This may be followed by baking and massage, but weight bearing is not permitted for a considerable period of time, three to six months (Speed) or two months (Scudder). Böhler[212] waits for six to ten days for the swelling to subside before he attempts reduction. With the patient under spinal

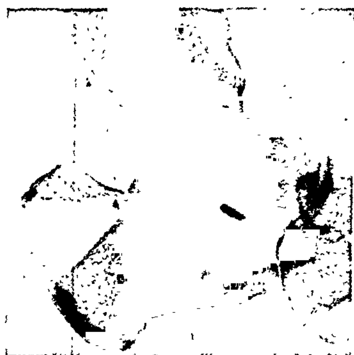


Fig. 474.—Avulsion fracture of the os calcis. (Courtesy of Dr. John T. Hart.)

anesthesia a compression bandage is used to diminish the swelling further. Impaction is broken up by molding the foot over a wedge and manipulating it laterally. Traction nails are driven through the proximal posterior corner of the tuberosity of the os calcis and through the tibia 4 fingerbreadths above the ankle joint. Traction and countertraction are applied by means of freely turning stirrups and a screw-extension device. Axial kinking, shortening and part of the broadening are reduced by traction in the long axis and then posteriorly in the long axis of the calcaneus. The remainder of the broadening is reduced by temporary lateral compression with a special kind of vise. When the roentgenograms show good overcorrection of the tuber-joint angle, unpadded plaster incorporating the nails is applied with the forefoot in pronation and plantar flexion. Forrester[213] has treated 150 fractures of the os calcis, and in none of them has a subsequent operation such as arthrodesis been required.[214]

In 1931 the author[215] called attention to fractures of the anterior process of the calcaneus (Fig. 475). Before this paper was published but after it was written and submitted for publication, the author discovered a paper by Dachtler[216] describing the same condition. The injury is probably caused by forcible plantar flexion of the foot. The treatment is immobilization in a circular plaster cast for three or four weeks followed by physiotherapy. Moore[217] describes fractures of the tuber calcanei involving the medial and lateral processes. He says:

> "Due to the fact that muscles of the plantar region of the foot tend to hold the frag- [illegible] are best maintained by some form of constant [illegible] incorporating a soft rubber ball in the cast in [illegible]

(e) *Fracture of the Sustentaculum Tali.*—Forcible inversion of the foot may break off or impact the sustentaculum tali into the cancellous bone of



Fig. 475.—Fracture of the anterior process of the calcaneus.[200]

the os calcis. The points in the diagnosis include tenderness localized over the sustentaculum, forced abduction of the foot, valgus position in walking, swelling on the inner side of the heel, pain in the heel on attempts at weight bearing and shortening of the heel by slight displacement of the os calcis forward. The treatment consists in the immobilization of the slightly inverted foot in plaster of paris for six to eight weeks. Speed[218] advises that a metal insole worn during the first three months of weight bearing may help strengthen the foot if it does not cause pain by pressure. Complicated or old fractures are subjects for major treatment.

Metatarsals and Phalanges.—(a) *Metatarsals.*—The metatarsals are very commonly fractured by direct violence as the result of the falling of a heavy object upon the foot (Fig. 476). Occasionally they may be broken by indirect or muscular violence.

The *base of the fifth metatarsal* is particularly liable to fracture (Fig. 477), which may be mistaken for a sprain.[219] The diagnosis of fracture of the base

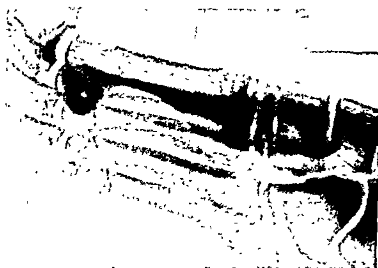


Fig. 476.—Greenstick fracture of the shaft of the fourth metatarsal.

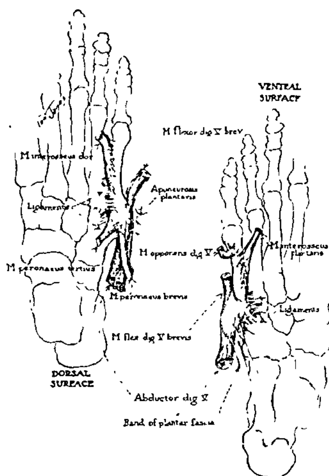


Fig. 477.—Showing anatomy of fifth metatarsal, ventral and dorsal surfaces. (Christopher, F.: Surg , Gynec. & Obst. 37: 190, 1923.)

of the fifth metatarsal is made certain by pain, swelling and tenderness on palpation at this area and by x-ray films (Fig. 478). The usual treatment is immobilization in a plaster cast for a period of two or three weeks.

According to Rogers,[220] who examined 50 patients, "an epiphysis for the styloid process of the fifth metatarsal bone occurs between the ages of ten and seventeen in 28 per cent of subjects."

The *os vesalianum pedis* has been studied by Davis,[221] who describes it as the "proximal and external part of the tuberosity of the fifth metatarsal." It is thought to be excessively rare (1 in 10 000 cases) and may be mistaken for a fracture of the base of the fifth [illegible] Davis[221] [illegible] er- [illegible] nd [illegible] ies are not sharp but rather smooth in outline. Some writers, however, consider the styloid epiphysis of the fifth metatarsal to be the same as the os vesalianum.

Carp[222] reported 21 cases of fracture of the fifth metatarsal bone. He considered that there was a tendency toward delayed union because of the poor blood supply. Carp believes that physical therapy should be instituted

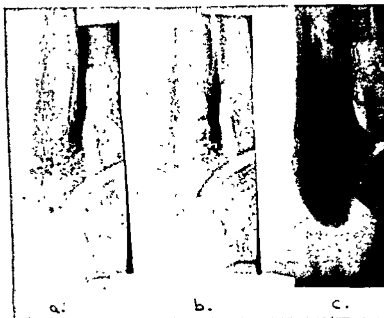


Fig 478.—Fracture of the base of the fifth metatarsal: *a*, Fresh fracture. *b*, Fifth metatarsal on the opposite foot. *c*, Healed fracture shown in *a*.

early and that weight bearing should be carried out before a month has passed in order to prevent bone atrophy. Cod liver oil should be given. Corbusier (discussion of Carp's paper) does not see the necessity of putting these fractures in plaster casts. Carp believes that scarification of the fractured bone ends by means of a needle introduced through the soft part to produce bleeding may stimulate union. When there is avulsion of a fragment at the base of the fifth metatarsal Ellis and Coulter[223] advise that the fragments be tacked in place under *x*-ray guidance.

For fractures of the shafts of the metatarsals the principles of Ellis and Coulter (*loc. cit.*) may be followed out. These authors believe that there should be effectual immobilization preserving or exaggerating the concavity of the foot in slight supination with traction of the forepart of the foot. This method not only will maintain extension in the metatarsals and thus assure the alignment of their shafts, but in the case of crushed tarsals will relieve pressure upon them and their injured ligaments and joint cartilages. These authors recommended the use of the splint devised by Dr. George G. Davis, of Chicago.

The splint is made of a curved board about ¾ inch in thickness. This is curved upward into the plantar concavity of the foot, the anterior end being sawed into separate projec-

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[illegible] forced

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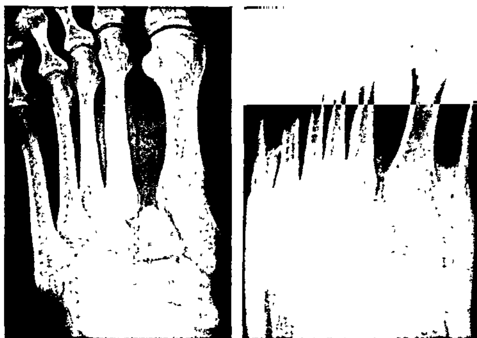


Fig 479 —Fracture of the base of the second metatarsal before and after reduction, with application of a plaster cast.



Fig. 480.—Leather arch support is secured with adhesive strapping. (Morrissey, E. J. J. Bone & Joint Surg. 28: 594, 1946.)

and across the ankle joint in front. The extension thus exerted overcomes the pull of the

[illegible] heal-

ig-

a-

As a rule the period of maintenance of splinting and extension with this appliance is four weeks, with a further period of from two to four weeks before weight is borne on the foot. Buka[224] advises that all metatarsal fractures be immobilized in a plaster of paris cast for at least three weeks. He says: "Use foot for full weight bearing guardedly, beginning with the end of the third week in single and simple metatarsal fractures. Use foot for full weight bearing guardedly after the fourth week in complicated fractures, however only

ization, particularly in injuries without displacement, result in delayed healing with excessive callus formation; this in turn may cause prolonged disability in weight-bearing. . . . When metatarsal fragments are *not displaced*, simple immobilization of the foot in a plaster boot is adequ

ten to fourteen days,

plaster casing to whi

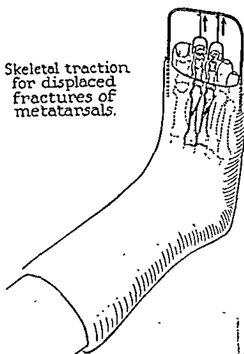


Fig. 481.—Oblique or over-riding fractures of the metatarsals. (Compere, E. L., and Banks, S. W.: Pictorial Handbook of Fracture Treatment, Chicago, Year Book Publishers, Inc., 1943.)

be molded carefully about the foot to afford support to the longitudinal arch. In most fractures without displacement a period of complete immobilization for six weeks is sufficient. At the end of that time, a shoe with a longitudinal arch support is adequate for protection and comfort.

"*Displaced metatarsal fractures* demand accurate reduction. This may be accomplished

is applied to the affected toe

about the toe affords a good

In the reduction as little manipulation as possible is done, reliance being placed principally upon extension. The after-care of fractures of this type consists in skilful massage and heat. The latter is given by means of a baker, a radiant heat lamp, contrast baths or diathermy. When the patient starts to walk, a plantar felt pad is worn, and he is instructed in exercises which strengthen the muscles and ligaments of the foot and ankle.[227]

Morrissey[228] treats metatarsal fractures by simply applying a leather arch support to the foot with adhesive strapping (Fig. 480). The skin is treated with three coats of tincture of benzoin before the adhesive plaster is applied. Immediate weight bearing was permitted in

57.4 per cent of his 61 cases, but a longer interval was required in the more severe cases. The strapping was renewed once weekly for four weeks, and thereafter the arch support was used for a month.

For fractures of the metatarsals with displacement or for fracture-dislocations of the metatarsals and metatarsal-phalangeal joints, Compere and Banks[229] say that reduction is obtained best by traction (Fig. 481).

(*b*) *Phalanges.*—Fractures of the phalanges occur from direct violence, either by the fall of a heavy object upon the toes or by the traumatism sustained in kicking the foot against a hard object. The chief difficulty in the treatment of this condition is the failure to realize its existence. In all cases of traumatism to the toes there should be *x*-ray examination (Fig. 482). If the position of the fragments is proper, recovery will occur with the minimizing of walking and with the employment of an adequately cut-out shoe.

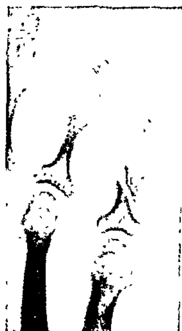


Fig 482.—Fracture of the proximal phalanx of the little toe.

Fractures of the distal phalanges, in particular, do not require splinting (Figs. 483, 484). Adhesive plaster splintage of the affected toe, so that it is relatively immobilized in regard to itself and in regard to the foot, is useful. Scudder[230] recommends a simple plantar splint of splint wood, padding of the toes and adhesive plaster straps and says that if the plantar splint covers the entire sole of the foot, it will prove of great comfort. Barnard[231] has described a method of altering old shoes by the insertion of a steel plate under the sole and over the toe, so that walking is possible without motion of the joints of the toe.

[illegible] These fractures are caused by a missten [illegible]

[illegible] condition does not [illegible]

[illegible] f the great toe [illegible] oentgenogram

shows the involved bone to be undivided, or unless subsequent roentgenograms or pathologic sections demonstrate the presence of callus. . . . Of forty-one patients on whom sesamoidectomy was performed for the relief of pain, we found that 41.5 per cent obtained [illegible] were definitely improved, making 70.8 per cent [illegible] ve patients, or 12.2 per cent, were not improved. [illegible] ved of their pain by the operation, but had their [illegible] ntly cut, thus acquiring a hammer toe deformity for which further surgical measures were indicated. Great care must be exercised in removing the bones from their tendons if this accident is to be averted, especially in double sesamoidectomy. Both sesamoids need not, and should not, be removed unless there is a clear indication for removing each one. To remove both increases the hazard of dividing [illegible] those cases of painful sesamoids which have failed to respond to conservative methods of treatment. The operation should be supplemented by *adequate post-operative physical* therapy in the form of massage and early motion at the joint."

For these fractures, Powers[233] says: "Conservative treatment is indicated, whether the symptoms be due to fracture or developmental anomalies. The prognosis for true fractures should be guarded."



Fig. 483.—Comminuted fracture of the distal phalanx of the great toe.



Fig. 484.—Fissure fracture of the distal phalanx of the great toe.

"This subject has been studied by Hobart,[234] who states:

"1. Fracture of the tibial (inner) sesamoid of the great toe, although not common, has been reported often enough since its recognition to be classed as a clinical entity.

"2. Fracture of the fibular (outer) sesamoid is rare and has been reported only a very few times.

"3. Congenital anomalies of the tibial (inner) sesamoid occur in about 4 per cent of cases.

"4. *No cases of congenital anomalies* of the fibular (outer) sesamoid have been reported."

In a later paper Hobart[235] reports another fracture of the fibular (external) sesamoid bone at the first metatarsophalangeal joint and states that "3 cases of congenital division of the fibular (outer) sesamoid bone of the great toe have been reported in the German literature."

Hobart reports a case of fracture of the fibular sesamoid bone and says that the treatment is immobilization in plaster of paris for three to six weeks. The cast may include the great toe. If immobilization fails "or if the symptoms persist, removal of the affected sesamoid bone or bones is indicated." (Hobart) Incision is made at the side of the foot.

Koch[236] says that the treatment of these fractures consists in rest in bed, early massage and hot air therapy and, when there is considerable callus, extirpation. According to Delagenière:[237] "The only effective treatment is extirpation of the fractured sesamoid. This is a very simple operation which can be performed under local *novocaine anesthesia.*

A small incision 2 or 3 cm. long is made on the inner border of the foot, the tendon of the flexor brevis is found, and the sesamoid is isolated and removed."

March Fractures (Fatigue Fracture, Stress Fracture).—Straus,[238] in speaking of "marching fractures" (*march foot*), says: "Fracture of the metatarsal bones may occur insidiously as a result of long-continued walking or standing," and "pain and callus formation later may simulate neoplasm." The second metatarsal is most commonly involved, but the third and fourth may be affected. There is pain, not of sudden onset, in the foot, with swelling of the dorsum. The average soldier may not report to sick call for several days after the onset of symptoms. Sweet and Kisner[239] say: "The earliest change noted on the roentgenogram is a thin, transverse, hair-line fracture through the cortex of the metatarsal bone. At times this line is so faint that it is necessary to use a reading glass to visualize the fracture. It is not uncommon in the early stage of the lesion for the roentgeno- [illegible] weeks of immobilization in plaster of paris followed by one or two weeks of physiotherapy.[240] Scott[241] says: "It is probable that a mild hypothyroid state may be a predisposing systemic cause in patients who develop march fractures. Cast treatment is not necessary, nor is it indicated except possibly in those cases in which the fracture line is complete. Bed rest continued through the period in which the inflammatory swelling is disappearing and continued for 2 days thereafter is the treatment of choice. The administration of thyroid substance for a short period is apparently helpful." His period of bed rest is five days. Bernstein and Stone[242] advise against the use of immobilization in plaster of paris. They advocate using a steel bar in the sole of the shoe to make it rigid. Hullinger and Tyler[243] prefer a lightly padded plaster cast from the tip of the toes to the middle of the leg and have used this type of cast in 274 cases. A walking iron was incorporated in the cast in some cases. Leavitt and Woodward,[244] who use plaster immobilization, say that their end-results have been poor and they conclude that march fracture in soldiers is more serious than reports have indicated. Leveton[245] put these patients at bed rest for three weeks, with two to four weeks of "reconditioning" thereafter.[246]

March fractures have been reported in the neck of the femur,[247] the shaft of the femur,[248] the tibia,[249] the fibula[250] and the calcaneus.[251]

Manipulative Surgical Treatment of the Lower Extremity.—This should be mastered by everyone who attempts to treat affections of the joints of the lower extremity. The details of this type of treatment fall beyond the scope of this book. For those who are interested, however, the writings of Fisher[252] are enthusiastically recommended.

Ingrown Toe Nail (Unguis Incarnatus, Onychocryptosis).—This common ailment, which is generally seen on the outer margin of the great toe, though sometimes on the inner margin, is almost always the result of wearing shoes or stockings which are too tight. In growing boys, short shoes are a frequent cause (Webb). An additional factor is often the ill-advised custom of trimming the corners of the nails off down below the skin edge. The skin at the corner of the shortened nail is subjected to repeated traumatization, and ulceration and infection invariably take place. When the condition is neglected a considerable amount of granulation tissue grows up from the ulcerated area, which occasionally may be controlled by using a silver nitrate stick. The condition is usually very painful, and the patient will often aggravate it by cutting off the visible corner of the nail, leaving a buried projection of nail, which only makes the matter worse (Fig. 485). The ingrown toe nail may be complicated by or confused with epidermophytosis ("athlete's foot"), a condition usually improved by the application of 1 per cent gentian violet.

The most important part of the treatment of ingrown toe nail is the prophylaxis. This consists of wearing shoes and socks of proper size and shape, and properly cutting the nails. They should be cut straight across or only slightly curved so that the nail itself projects beyond the skin. The nail should

not be trimmed by cutting far down into the corners at the skin edges, nor should it be cut too short. In early and mild conditions with a slight amount of infection a day of warm boric acid fomentations and the subsequent



Fig. 485.—Improper and proper methods of cutting the toe nails.

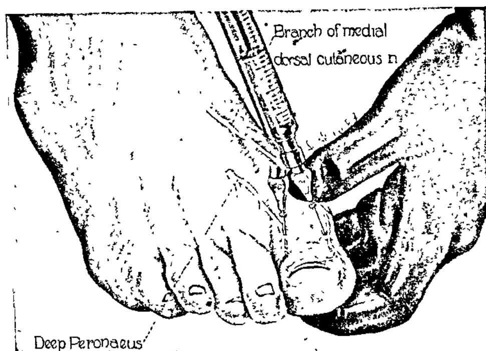


Fig. 486—For removal of toe nail or other operative procedures on the great toe anesthesia is produced by depositing 4 to 6 cc. of a 1 per cent novocain solution about its base. (Pitkin, G. P.: Am. J Surg. 8: 239, 1930.)

wearing of a shoe with a cut-out toe will generally be sufficient. The foot is washed with soap and water twice daily and rinsed with alcohol. Vaughan and Burnham[253] advise that "if infection occurs, most cases can be cured by packing a small wick of cotton between the edge of the nail and the skin

and beneath the nail in such a manner as to avert the edge of the nail." Dolan[254] impregnates the cotton wick with tincture ferri perchloride. Mickel[255] introduces a piece of gauze soaked in celluloid solution under the ingrowing part of the nail and repeats this procedure in a few days.

Some patients have cured themselves by allowing the nail to grow so long that it curves over the end of the toe by pressure of the shoe or sock. This tends to force the lateral edges of the nail upward. (Vaughan and Burnham) A very simple and often curative method of treating ingrown toe nails is the avulsion of the entire toe nail with the patient under gas anesthesia. The ulcerated nail sulcus has ample time to heal as the new nail is growing out, and there may be no recurrence. The convalescence is longer however. The older standard operation consisted in the removal of a wedge of skin and nail (Fig. 487, *b*), but it has the disadvantage of prolonged morbidity.

Winograd[256] has reported a method of treating ingrowing toe nails which is so rational and simple and has given such good results in his hands and also in the author's, that the method as described in his article is reproduced here verbatim:

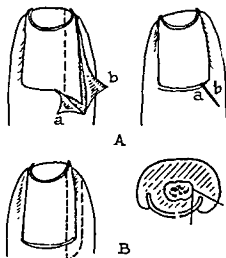


Fig. 487.—*A*, Winograd operation for ingrowing toe nails. The paronychium is not resected. *B*, Older operation for ingrown toe nails.

"1. A tourniquet, which serves both to make the field bloodless and act as a partial nerve block, is applied at the base of the toe. A small piece of rubber tubing is best for the purpose. [Use of a tourniquet is not advised.—F. C.]

"2. Sterilization of the field is obtained by iodine and alcohol.

"3. Anesthesia is produced by the injection of 0.5 per cent procaine at the base of the big toe on both sides down to the bone, thus blocking off the nerves to the part to be operated on (Fig. 486).

"4. A small incision is made in the soft tissue of the nail fold and eponychium on a line with the incision to be made in the nail, and extending back to the matrix.

"5. Chiefly by blunt dissection, the soft tissue is separated from the ingrowing piece of nail until the lateral margin of the nail is reached. This piece of tissue, which previously was removed, is retracted and preserved.

"6. With small pointed scissors the nail is cut about ⅛ to ¼ inch from the visible margin,

"9. The wound is then treated with mercurochrome and packed with a small piece of sterile petrolatum gauze. The tourniquet is removed and the soft tissue replaced.

"10. Daily dressings for a few days are necessary, after which the toe may be dressed every two or three days.

"In cases in which there is marked swelling and suppuration it is advisable to soak the foot in hot water containing boric acid for several days before the operation. Pain during the first night after the operation may be relieved by a barbital preparation, although this is often not necessary if the technic described is employed. Throughout the post-operative course the toe maintains a practically normal appearance. A small incision in the eponychium is the only visible evidence of the operation, whereas by the old method there is a raw, open surface, usually infected. The swollen overgrown tissue returns to normal size, and soon has the same appearance as the tissue on the unaffected side. With proper care infection should not be present, and there is little danger of extension from previous infection as no wide blood channels are opened. Within a few days the patient should be walking on the foot." The author omits the petrolatum gauze packing when doing a Winograd operation.

Winograd[257] followed for eighteen months 20 patients with ingrown toe nails operated on by his method. Thirteen (65 per cent) were cured, 4 (20 per cent) were improved and 3 (15 per cent) had recurrences. While Winograd

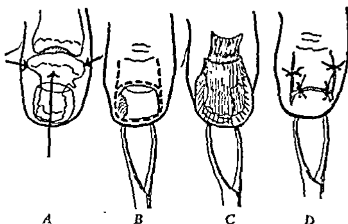


Fig. 488.—*A*, arrows point to sites of injections for anesthetic. *B*, sites of incision. *C*, elevation of flaps and excision of nail. *D*, suturing of flaps. (From Wardleworth, H. C.: Lancet 2: 100, 1941.)

thinks other operations may have a higher percentage of permanent cures, his method is to be recommended because of the simplicity of technic, relative loss of time and absence of complications. Clarke[258] has had excellent results with the Winograd operation in 31 cases, all with healing by primary intention. He attributes a good part of his success to prolonged scrubbing of the entire foot with a hand brush and tincture of green soap before the operation. In a later report Clarke and Dillinger[259] said they found healing by first intention in all of 269 cases. In 29 closely followed cases there were 9 recurrences, with only 2 with symptoms. In 240 cases in which operation was performed under field conditions without systematic follow-up, only 1 recurrence was observed.

In cases of gross deformity, Dolan[260] eradicates the nail and nail bed and covers the raw area with small full thickness skin grafts. Wardleworth[261] removes the entire nail and nail matrix at the upper end. Previously-fashioned skin flaps are now approximated so as to cover the whole bed area. (See Fig. 488.) Wilson[262] has had excellent results in 36 cases after removal of the nail, the matrix of the nail root and the hypertrophied paronychial tissue.

The technic of Whitesell[263] is shown in figures 489 and 490. In the Bartlett[264] operation a wedge of skin and subjacent soft tissue is excised along the side of the toe and is sutured primarily. This pulls the soft tissues away from the nail and is useful when there is no infection. In all operations for ingrown toe nails it is important not to bandage the toe too tightly. Death from septicemia has been known to follow an operation for ingrown toe nail.[265]



Fig. 489.—New "shark-fin" onychotome with double cutting-edge blade.

Osteochondritis of the Epiphyses of the Lower Extremity.—*Osteochondritis of the Head of the Femur (Perthes' Disease; Osteochondritis Juvenile Coxae; Legg's Disease).*—This condition, which formerly was confused with tuberculosis, was thought by Legg,[266] who first described it, to be due to trauma which caused a disturbance in the circulatory relationship between the femur and its epiphyses. This was thought to bring about atrophy of the epiphysis through a diminished blood supply. Jones and Lovett,[267] and Sutro and Pomeranz,[268] are inclined to agree with the traumatic origin of this condition.

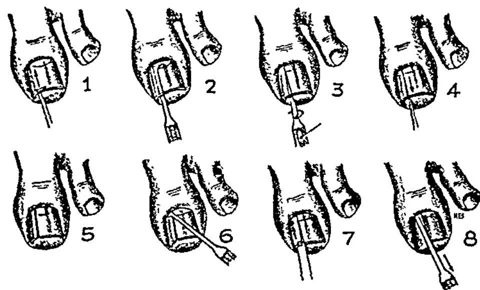


Fig. 490.—Detailed operative technic for employing new instrument. *1* and *2*, Insertion of instrument beneath nail; *3*, Rotation of blade to vertical; *4* and *5*, Withdral of instrument and splitting of nail; *6*, Separation of eponychium; *7*, Separation of segment being removed from nail bed; *8*, Curettage of nail matrix. (Whitesell, F. B.: Surgery 18: 660, 1945.)

Others believe that the origin is infectious. As pointed out by Harbin and Zollinger,[269] "It usually occurs in very active well-developed boys between the ages of three and twelve years, although girls are not exempt. The first symptom is a limp on the affected side, and this may be accompanied by local pain and tenderness." The *x*-ray appearance is characteristic. The epiphysial head shows areas of rarefaction, fragmentation and marked flattening (Fig. 491).[290] The neck of the femur shows thickening and shortening.

The treatment consists of restriction or prohibition of weight bearing. Danforth[271] urges that there be no weight bearing "until the bone structure has become normal." In cases of severe involvement, the patient may be put to bed in a plaster spica. Later he is permitted up on a Thomas ring walking caliper. After a sufficient period of rest, four to ten weeks, he will be symptomatically cured, and the roentgenogram will show the formation of a new rounded head (Fig. 492).

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crutches without weight-bearing on the involved leg. This type of treatment is readily available, inexpensive, and with reasonable cooperation will give good results. Since it is an ambulatory method of treatment, it is more readily accepted than recumbent or more encumbering types. The patient must be impressed, however, with the importance of walk-



Fig. 491.—Legg-Perthes' disease. Note the flattened head, dense epiphysis and wide femoral neck in contrast to the normal hip on the opposite side.

ing on the crutches and well leg, and he must not walk or kneel on the involved leg. If the patient has only a *moderately restricted* range of motion without muscle spasm, this treatment is started immediately. If there is an abduction contracture or considerable muscle spasm, the patient is treated with *preliminary* traction for several weeks, until muscle relaxation and abduction are obtained. The hip is then immobilized in an abduction spica for three to four months, after which the patient is allowed up on crutches with an elevation under the well leg and no weight-bearing on the involved hip. Relatively few of the patients have sufficient hip deformity to warrant the preliminary traction and cast treatment.

"It is felt that in cases of Legg-Perthes' disease treatment as outlined for such a pro-

reas treatment in recumbency
cannot be applied to a large

An *acute transient epiphysitis* of the hip joint is described by Miller.[275] According to this author, "it is a common cause of hip complaint in children. It is usually provoked by mild trauma. It may be suspected in a child complaining of pain about the hip if he has diseased tonsils or has recently had an acute infectious disease. Carefully made roent-

genograms will show small abscess formation and absorption about the epiphyseal line. The treatment consists of the removal of infectious foci, rest from weight bearing, and traction on the lame limb. Duration of the disease is from a few weeks to a few months, and if prompt treatment is instituted, children recover without any disturbing changes in the hip joint."

Osteochondritis of the Patella (Larsen-Johansson Disease).—In this condition there is an accessory center of ossification at the lower pole of the patella, causing a potential mechanical weakness at the upper end of the ligamentum patellae (Fig. 493). Hawley and Griswold[276] report a case of Larsen-Johansson disease of the patella in a boy 12 years of age who complained of intermittent



Fig. 492.—Convalescent Legg-Perthes' disease. Note the formation of a new rounded epiphysis.

pain and a limp, following a mild strain of the left knee. Physical examination revealed only tenderness confined to the lower margin of the patella. On x-ray examination a small accessory center of ossification was found in the lower pole of each patella, but this finding was most distinct in the right knee, which had been free from symptoms. The treatment consisted in support of the left knee by adhesive plaster and restriction of activity for one month. At the end of that time the knee appeared to be normal. Five months later the patient returned complaining of pain in both knees after playing football or riding a bicycle. Swelling and tenderness were found at the lower borders of both patellae. On the left side a bony enlargement was apparent. x-Ray examination showed pear-shaped patellae with well marked knobs on the lower poles, where fusion of the separate ossification centers to the main bone was well advanced. Under the same treatment as that

given before, the symptoms promptly subsided. Cox[277] points out that "diffuse osteochondritis of the patella can result from trauma" and recommends patellectomy in persistent cases.

Hawley and Griswold call attention to the following resemblances between this condition and Osgood-Schlatter's disease: (1) In both conditions there is an anomalous bone formation. In Larsen-Johansson disease this is in the form of an accessory center of ossification, whereas in Osgood-Schlatter's disease it is manifested by the beak-shaped tibial epiphysis. It suggests a mechanical weakness at the upper end of the ligamentum patellae in the former condition and a similar weakness at the lower end of this ligament in the latter condition. (2) The two lesions are the results of continued strain on the patellar ligament and are usually not associated with sudden trauma. (3) The clinical signs and symptoms, roentgen findings, course, prognosis and indicated treatment are similar.[278]



Fig 493.—Larsen-Johansson disease of the patella. (Courtesy of Dr. F. A. Chandler and Dr. J. T. Case.)

A case of *Köhler's disease of the patella* has been reported by Moffatt[279] (see Fig. 494).

Osteochondritis of the Proximal Epiphysis of the Tibia (*Osgood-Schlatter's Disease; Tibial Tubercle Apophysitis*).—In this condition, which was described by Osgood[280] in 1903 and by Schlatter[281] in 1908, there is partial separation of the tibial tubercle which may be due to trauma, sudden muscular effort or long continued exercise of the quadriceps. Uhry[282] made a careful study of 79 cases and found the onset of symptoms was most frequently in the age period of 11 to 13 years and that there were 66 boys and 13 girls. He stated: "This study of Osgood-Schlatter disease leads me to the conclusion that the disorder develops on the basis of a minor separation of structures, one from another, in the complex comprising the tibial tubercle and patellar ligament and that the characteristic pathologic changes represent scar-callus repair at the site or sites of separation. The separation may be a clean one or may entail the inclusion of bone fragments in a softer part, as it is torn free.

Any interface or combination of interfaces in the complex can be affected, but the majority of separations occur at the ligament-apophysis face, the anterior apophysial surface. Occasionally, a fracture of the very tip of the tubercle is also found, with healing or with the formation of a pseudarthrosis, in association with the processes of repair of the disruptions at the interfaces. Inflammation (specific or nonspecific), osteochondritis, and endocrine, vascular or other specific changes are not in evidence. There seems to be no factor predisposing toward the condition other than the normal weakness of the part and its relative inadequacy to the exigencies of function and poor resistance to trauma at the time of life (usually puberty) when the disorder appears. The immediate instigating factor is consistently trauma."

According to Vigholt,[283] none of the numerous and divergent theories which have been put forth to explain the pathogenesis has satisfactorily solved the problem. Cole[284] believes the underlying cause is rapid growth during convalescence. Hypothyroidism has been thought to be a factor.[285]



Fig. 494.—Köhler's disease of the patella. (Moffatt, B. W.: J. Bone & Joint Surg. 11. 579, 1929.)

The symptoms may come on suddenly or may develop slowly. Local pain over the tibial tubercle, swelling and difficulty or inability to extend the leg are noted. Limping may be present. The *x*-ray appearance may or may not be characteristic; both knees should be examined roentgenologically.[286] The condition occurs at the ages of from 10 to 16 years, chiefly in boys, causing tenderness and swelling at the tibial tubercle. Extension of the leg causes pain at the tibial tubercle. The symptoms may be very severe so as to give rise to the suspicion of osteomyelitis. In the differential diagnosis, tuberculosis, bone cyst and pretibial bursitis also must be considered. The treatment consists in relative or complete immobilization of the knee joint. The milder cases are satisfactorily treated by painting the skin with compound tincture of benzoin and then applying long 1 inch wide strips of adhesive tape on the anterior side of the lower extremity from just below the groin to just above the ankle. Lateral strips are added to make the longitudinal strips more secure This treatment practically eliminates flexion of the knee, and the resultant strain on the tibial tubercle with extension. The strapping may have

to be changed several times before a cure is effected. In the more severe cases a well fitting circular plaster cast is used. The cast should be worn for six weeks, and after that, violent exercise should be prohibited for a period of two to four months. Walking may be permitted while the cast is worn. After its removal Ollerenshaw[287] advises massage and walking for six weeks with the use of a knee cage with a stop at 45 degree flexion. Jones and Lovett recommend 30 degrees. The author has used the adjustable knee flexion leg brace in the case of an active boy, who, after this immobilization in plaster of paris, went to a ranch in the western United States and indulged in very active and continuous horseback riding. The result was a complete cure. Jones and Lovett[288] recommend a back splint strapped to the leg with adhesive plaster, the tender area being avoided. Osgood believes that adhesive strapping is generally sufficient to cure this ailment without the use of plaster of paris. The subjective symptoms are more reliable than the x-ray appearance in an estimation of the recovery.

Osteochondritis (Osteochondrosis?) Deformans Tibiae (Tibia Vara).—Blount[289] has reported 13 cases and has added 15 cases cited in the literature of osteochondritis at the medial side of the proximal tibial epiphysis. The varus deformity causes confusion with rickets. Blount says: "Treatment



Fig. 495.—Osteochondritis of the tarsal scaphoid bones (Köhler's disease). (Harbin, M., and Zollinger, R.: Surg., Gynec. & Obst. 51: 145, 1930.)

should be directed toward the mechanical relief of strain until the deformity is stationary or until the epiphysis is closed. A simple osteotomy is desirable in the correction of marked deformity. . . ."

Osteochondritis of the Scaphoid (Köhler's Disease; Tarsal Scaphoiditis).—Köhler, of Wiesbaden, in 1908 described a peculiar "developmental anomaly" of the tarsal scaphoid bone. It most commonly occurs between the ages of 3 and 7 years and is accompanied by pain, which is made worse by exercise. There may be a tender red swelling over the scaphoid bone. According to Harbin and Zollinger,[269] this condition rarely appears before the fourth year and not after the twelfth year. The first symptom is a limp. "Roentgenograms show the bone to be decreased one half to one fourth the normal size and irregular in shape (Fig. 495). The bone is increased in density and the normal architecture is lost. The spongy and cortical portions are indistinguishable. Gradually fresh bone develops around the condensed nucleus." (Harbin and Zollinger)

The structure of the bone itself is irregular and dense. Konjetzny[290] agrees with Axhausen that in Köhler's disease, Perthes' disease and necrosis of the semilunar bone, there is subchondral epiphysial necrosis with little or no destruction of cartilage.

Various treatments, even operative, have been advised. Ely[291] says that complete recovery "always takes place with any treatment." The symptomatic treatment is probably the best. The child with mild symptoms is put to bed until the tenderness and pain have disappeared. A plaster cast will insure rest until the patient is symptom-free. "When there is considerable pain upon weight bearing it is necessary to apply a plaster boot with moderate elevation of the long arch. The splint should be worn about three weeks and followed by the application of a soft inner sole, long arch support, and ¼-inch elevation of the inner side of the heel." (Harbin and Zollinger[269]) Ely[291] has pointed out that "roentgen ray examination shows that the apparently hopelessly damaged bone slowly develops and becomes normal in structure and shape." Karp[292] says: "Complete regeneration of the involved bone takes place in an average of two and three-fourths years, and a normal foot is the usual end result."

Osteochondritis of the Metatarsals.—In this condition there is a painful destructive process of the head of the second metatarsal, *Freiberg's infraction.* It "occurs most often in females between the ages of ten and fifteen years. Local pain on walking referred to the part affected is the chief symptom. Localized tenderness, periarticular thickening and swelling are present. Plantar flexion of the foot may be limited. The onset often follows a strenuous tennis game in which the ball of the foot must repeatedly stand the impact of the body. Disturbed mechanics of the foot due to high heels has also been suggested as a cause. The first metatarsal escapes because the epiphysis is located at the proximal end. Involvement of the second metatarsal is more common than of the remaining three because it is longer than the rest and bears the brunt of the body forces. Roentgenograms are diagnostic. The head of the second metatarsal is flattened and irregular. Alterations in the structure of the head, condensation, and rarefaction give the appearance of fracture at times. The cortical portion of the diaphysis usually shows thickening.

"Relief is ordinarily afforded by a transverse leather bar ⅜ inch thick upon the shoe just back of the position of the head of the metatarsals of the affected side with a moderately low heel. This serves to remove the weight from the part. In the severe type where loose bodies are present, their surgical removal with partial excision of the head of the metatarsal is required." (Harbin and Zollinger[269])

The condition is not unlike Köhler's disease, as it has a tendency to undergo spontaneous cure. The *x*-ray appearance is characteristic. Mouchet[293] says that the *x*-ray evidence should be the guide to treatment. Occasionally immobilization in plaster may be necessary, the patient being allowed to walk on crutches. If osseous repair is adequate at the end of six months, careful walking should be allowed. A case of epiphysitis of the proximal epiphysis of the fifth metatarsal has been reported by Burman and Lapidus.[294]

Osteochondritis of the Os Calcis (Apophysitis).—According to Harbin and Zollinger,[269] whose studies on the subject of osteochondritis have been extremely valuable, "this disturbance occurs most frequently in very active boys, from eight to fourteen years of age. These patients complain of pain about the heel upon walking. This is many times severe enough to cause a limp. Examination reveals pain and tenderness over the back of the heel. There may be thickening of the overlying soft tissues. Full dorsiflexion is

limited and any strain on the *tendo achillis* causes pain. A history of direct trauma is not often obtained.

"Roentgenograms may show a widening and cloudiness between the epiphysis and body of the os calcis. The epiphysis is often enlarged and irregular in outline; areas of condensation and rarefaction occur (Fig. 496).

"This condition may be confused with a bursitis due to the irritation of a shoe. Tuberculosis generally affects the anterior portion of the os calcis. Other inflammatory disease of the Achilles tendon can be ruled out by *x*-ray and the duration of the symptoms.

"As in all other types, this condition disappears when the epiphysis joins the diaphysis. However, some relief may be obtained by lifting the heel ¼ to ½ inch, as well as giving a small inner side lift to the heel if any pronation of the foot is present. A soft felt or rubber pad may be placed under the heel. Local pressure produced by several vertical straps of adhesive passing around the heel may give relief."



Fig. 496.—Osteochondritis of the os calcis. "Characteristic irregularity, enlargement, and mottling of the calcaneal epiphysis." (Harbin, M., and Zollinger, R.: Surg., Gynec. & Obst. 51: 145, 1930)

Meyerding and Stuck[295] say: "The treatment of this condition is palliative and, fortunately, is extremely simple. As a general measure, any focus of infection should be removed. Local heat and massage to the feet in the interval of acute pain may relieve the pain somewhat. But the most efficacious treatment consists of elevation of the heels to relieve tension on the Achilles tendon. Heel pads in the shoes are also of benefit, and avoidance of any strenuous exertion is indicated until the acute phase of the condition is over. In the more severe or resistant cases it may become necessary to immobilize the foot, in slight plantar flexion, for several weeks with plaster-of-paris casts. Following this, the heels of the shoes must be raised to prevent any recurrence of symptoms. Symptoms subside promptly under such a regimen and, as mentioned before, the condition disappears when the patients reach the age of 17 years, when the epiphyses become completely united."

Osteochondritis Dissecans.—Fairbank[296] defines this condition as "a condition in which a fragment of articular cartilage and subchondral bone becomes separated, partially or completely, from typical positions at the ends of certain long bones."

Trauma is a common cause, but a history of trauma is by no means always obtained. The joint most commonly affected is the knee, but similar lesions

have been found in the elbow, ankle and hip and even in the head of a metatarsal. In some cases the condition is bilateral (Fairbank). Balensweig[297] reports a case of osteochondritis dissecans involving the entire articular surface of the distal end of the femur in a girl of 19 years. Outland and Flood[298] report 2 cases of osteochondritis dissecans of the acetabulum. Fairbank believes that in the knee a blow on the tibial spine causes the process and thinks the typical lesion is a fracture. Osteochondritis dissecans of the astragalus has been reported by Lewis.[299] The diagnosis is based on the characteristic x-ray findings and on pain. With regard to the treatment Fairbank states that in the absence of symptoms the finding of a typical lesion in a roentgenogram is not a sufficient cause for opening the joint. However, it is extremely unlikely that this discovery will be made except in the course of routine roentgen examination in a case of bilateral involvement.

In the presence of symptoms the joint should be explored, and free or loosely attached bodies should be removed. Conway[300] says: "The optimum time for surgical intervention is during the period of demarcation before any great degree of synovial change has occurred." The prognosis is good for some years, but the remote prognosis is less favorable because of the likelihood of arthritic changes.

Tophaceous Gout.—Linton and Talbott[301] believe that less than 10 per cent of all gouty patients need surgical treatment. This treatment is limited to the removal of the urate deposits. Their indications for surgical treatment are as follows: (1) cosmetic reasons, (2) pain in the tophi, (3) interference with movements of tendons or adjacent joints, (4) discharging sinus from a tophaceous deposit, (5) extensive phalangeal involvement. Complete excision of the tophus with its surrounding capsule is preferred with curettage as a second choice. Christopher and Monroe[302] report a case of gout in which there were ulcerated tophi on both heels. These lesions had five times previously been incised on the supposition that they were pyogenic. The smear of the discharge showed uric acid crystals.

FIRST AID IN MAJOR SURGICAL INJURIES OF THE LOWER EXTREMITY

Severe crushing wounds and traumatic amputations of the lower extremity may occasion such profuse hemorrhage that death will eventuate unless

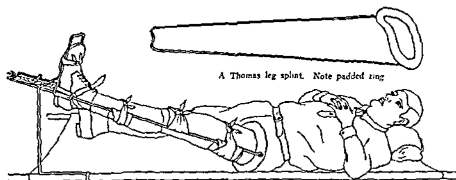


Fig. 497.—Thomas splint for transportation and first-aid treatment of fractures of the leg and thigh. (Committee on Fractures, Bull. Am. College Surgeons 15: 3, 1931.)

proper first-aid measures are taken. These will consist of the application of a tourniquet above the bleeding point and the treatment of shock. The patient will be removed to the hospital as rapidly as possible.

In cases of fracture of the femur the first-aid treatment consists in the proper application of a Liston splint. This splint is simply a strong, well padded board which extends from the axilla to the sole of the foot. It is firmly bandaged to the thorax and abdomen and is continued on as a spica round the thigh, leg and foot. Where first-aid conditions permit, the proper application of a Thomas traction splint is preferable (Fig. 497). The Keller-Blake hinged half-ring modification of the Thomas splint is excellent.[303] Once the splint has been applied it will be more important to treat shock if it is present than to speed up the transportation of the patient to the hospital.

In cases of fracture of both bones of the leg the first-aid splint should extend from the groin to well below the foot.

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CHAPTER XXII

INFECTIONS, TUMORS AND DEFORMITIES OF THE LOWER EXTREMITY

INFECTIONS

Cellulitis, Lymphangitis, Boils, Carbuncles and Abscesses.—The diagnosis and treatment of these conditions have been described previously.[1] (See Lymphangitis of the Foot, Deep Plantar Phlegmons.)

Acute Suppurative Tenosynovitis.—This condition is far less common in the lower extremity than in the upper because the feet are protected by shoes and because the hands are exposed to far more numerous traumas. The principles of treatment are the same, however, as for the upper extremity, and the perils of the infection are as great.

In the foot, as in the hand, there are three general types of infection, and more than one may be present at the same time. These, which have been carefully studied by Grodin-

over the proximal or middle phalanx and a small incision made through it. The serous sheath is then incised at that point and, if pus is obtained, opened its entire length by following a probe both ways. Instead of one continuous incision through the fibrous and serous sheaths, separate incisions may be made over the middle and proximal phalanges

web extends to the proximal interphalangeal joint and the sheath over the second phalanx is the only part in the free portion of the toe. Furthermore, since the second phalanx is lifted off the floor, the question of plantar scar on it is unimportant.

"Infections of the long flexor tendon sheaths should be drained by incisions directly over them behind the medial malleolus This is best accomplished by a small incision over the point of greatest localization in order to identify the sheath and then following down its whole length, a probe being used as a guide. It will be necessary to cut the annular ligament in this incision, but anything short of this will give insufficient drainage and the cutting of this ligament, in my opinion, leads to no serious loss of function. The posterior tibial vessels and nerve must be carefully sought for and preserved in making these incisions because of their superficial position, particularly in opening the sheath of the flexor hallucis longus tendon which lies just deep to them within its fibrous canal, the roof of which must also be incised.

lying just posterior to the sheath should be preserved. Where there has been a spread through a normal communication or break into the plantar sheath, the latter should be opened also. This is best accomplished by exposing and opening its proximal end, introducing a hemostat distally within the sheath and spreading the blades apart, thus eliminating the incision through the plantar surface and through all the layers of muscle with resulting poor drainage and plantar scar. If this sheath is being opened independently of the mal-

leolar sheath, the proximal end may be found at the lateral border of the abductor digiti quinti muscle 2 to 3 cm. posterior to the base of the fifth metatarsal bone. If it is necessary to drain the median plantar spaces, this is best accomplished by a medial incision along the anterior surface of the first metatarsal bone, lifting up the abductor hallucis and flexor [illegible]

"The sheaths of the extenser terdens are drained by incisions directly over them and extending their entire length, cutting through the anterior portion of the annular ligament."

Lymphangitis of the Foot.—In the lymphatic type of foot infections, that is, those of peridigital origin, the "portal of entry is through lesions about the toes, usually on the plantar surface. The common infective organisms are the Streptococcus haemolyticus and the Staphylococcus aureus. The routes of spread are the fascial spaces, . . . and the lymphatic channels accompanying the long or short saphenous veins. . . . The treatment of lymphatic infections is conservative until localization has occurred." (Grodinsky) Sulfonamides and/or penicillin will be used.

Deep Plantar Phlegmons.—Constantini and Liaras[4] have called attention to the seriousness of plantar phlegmons and say that every one is an indication for immediate surgical intervention. Deep plantar phlegmons usually spread posteriorly in the calcaneotibiotarsal canal and upward between the two muscular layers of the calf, usually stopping at the ring of the soleus. Tibiotarsal arthritis is a common complication, and thrombosis of the vessels in the calcaneotibiotarsal canal may occur. For the treatment of a marginal abscess of the foot affecting the abductor of the fifth toe, a large incision made early usually suffices. For a deep phlegmon that has not invaded the calcaneotibiotarsal canal, the sole of the foot should be incised from end to end, following the zone of greatest pain and stopping at the tibiocalcanean canal. A dorsal counterincision, if there is edema of the back of the foot, is recommended. If the plantar phlegmon has spread to the calcaneotibiotarsal canal, an initial malleolar incision curving around the malleolus and just in contact with it should be made and the suppuration exposed. From here the purulent fistula should be traced in both directions. If the fistula follows the flexor tendon of the large toe, the incision should follow this tendon up to the digitoplantar fold. If, as usual, the suppuration spreads over the sole of the foot, the incision follows the axis of the foot parallel to the third interosseous space. Toward the leg the incision follows the interior surface of the tibia. The interior gastrocnemius is pushed back, and the tibial insertions of the soleus are detached, extensively exposing the deep vasculonervous tissues of the leg. In case of dorsal edema, a dorsal incision is advisable; and if pus has spread in front of the Achilles tendon, an external incision behind the fibula is recommended. In case of synovitis of a toe or infection of a crushed toe with involvement of the plantar region, the sole of the foot should be incised in the direction of the calcanean canal to the end of the purulent fistula. If there are osteoarticular complications, the tibiotarsal joint must be opened and the talus removed for drainage. Osteitis of the metatarsals demands amputation. If the general condition is alarming, amputation is the wisest procedure even if only tibiotarsal arthritis is found.

Osteomyelitis is of frequent occurrence in the long bones of the lower extremity. The diagnosis and treatment are given elsewhere (see Fig. 498).[5]

Perforating Ulcer of the Foot (Mal Perforant).—In this condition there is a perforating ulcer on the plantar surface of one foot. Occasionally it is bilateral. It is generally situated in the neighborhood of the metatarsophalangeal joint or the pulp of the great or little toe. DaCosta[6] believed that the lesion is dependent upon both. It occurs with nerve lesions, diabetes, rheu-



Fig. 498.—Osteomyelitis of the sesamoid bone of the great toe. Cure followed operative removal.

matism, syphilis, arteriosclerosis and peripheral neuritis. The ulcer begins in the neighborhood of a corn and is accompanied by suppuration.[7] Numerous treatments, including periarterial sympathectomy, have been advised, but rest in bed with continuous hot boric acid fomentations is very useful. A permanent cure is difficult. Attention should be directed to the underlying



Fig 499.—Bilateral trophic ulcers of the feet. (Foor, C. G.; Allen, E. V., and Morton, S. A.: Proc. Staff Meet., Mayo Clin. 6: 361, 1931)

general condition, which should be treated if possible. For the local treatment, Vaughan and Burnham[8] advise that "the thick horny layer of epidermis should be removed with a sharp knife or by repeated applications of salicylic ointment (10 to 20 per cent). The ulcer may then be packed with gauze soaked in balsam of Peru or some other stimulating agent. The gauze should be

changed at frequent intervals. If this treatment is carefully carried out, and the patient is kept off his foot during the period of treatment, af ew cases may be cured."

Ainhum (Dactylolysis Spontanea).—This rare condition, which occurs chiefly in Africa, [illegible] Perhaps [illegible] lly be- [illegible] end in [illegible] tudinal [illegible] incision into the furrow.

[illegible] Trichophytosis).—A ring- [illegible] a study of [illegible]

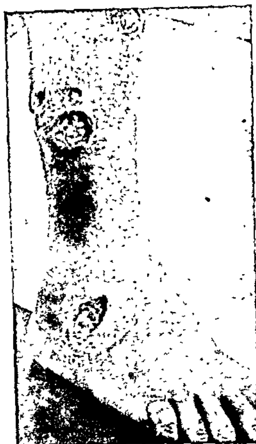


Fig. 500.—Tertiary lues. (Courtesy of Dr. Edward A. Oliver.)

"In all chronic cases which remain moist and in which delayed healing is associated with blebs and a scaling epidermis, the presence of the tinea should be suspected. The infection usually responds to treatment directed at keeping the wound dry and supplemented by the use of such topical applications as tincture of iodine, ammoniated mercury, and Whitfield's ointment (salicylic acid, 2; benzoic acid, 4; petrolatum, 30). Ringworm dermatitis of the extremities is a frequent atrium for secondary infections, many of which become serious."

Rademacher[11] describes his experiences with sulfathiazole in the treatment of ringworm (*trichophyton*) infections of the foot. In a battalion of 570, there were found 75 cases of trichophytosis ranging from a mere scaling with slight fissures to macerated swollen feet with large fissures and crusting. Half of the group were treated with pure sodium sulfathiazole crystals dusted on the lesions daily and half with 50 per cent sulfathiazole in talc. The condition of practically all the patients was definitely improved within forty-eight hours. Thereafter half of the patients were treated with 50 per cent and the other half with

25 per cent sulfathiazole in talc. [illegible] percentages (5 to 10 per cent) of [illegible]

[illegible] being treated for a short time and obtaining much improvement responded no further. These patients were further treated with 10 per cent of powdered sulfathiazole in a 2 per cent salicylic acid ointment. The length of treatment varied from two weeks to a month. Five were lost to follow-up, 33 were cured and 6 are still resistant. If the 14 patients lost to follow-up are not considered, 55, or 90 per cent of the 61 remaining patients, were cured. Taylor[12] recommands "S.S. ointment," which is made up as follows: salicylic acid, 350 Gm.; precipitated sulfur, 300 Gm.; petrolatum, 2,000 Gm.; cornstarch. *q.s.* One cup [illegible]

[illegible] in a closed tin box contain- [illegible] even at room temperature. [illegible] which it gives off again for many hours afterward. When shoes so treated during the night are worn during the day, a distinct amelioration or disappearance of infection of the skin may result after a time. Incidentally, the feet are also protected against reinfection from the shoes.

Syphilis of the Lower Extremity.—Syphilis has been described elsewhere (Fig. 500).

Gonorrhea of the Lower Extremity.—*Keratoderma blennorrhagicum* is a cutaneous manifestation of chronic gonorrhea. The treatment is directed toward the generalized infection; locally salicylic acid ointment is employed. Gonorrheal arthritis commonly affects the knee joint.

TUMORS

Sebaceous Cysts, Lipomas and Fibromas.—The diagnosis and treatment of these conditions have been described previously.

Angioma.—This is a vascular tumor rarely found in the lower extremity. The treatment is identical with that of angioma described elsewhere. According to Burman and Milgram[16] angiomas have been found involving the tendon of Achilles, the extensor of the fourth toe, the semitendinosus, the quadriceps, an anomalous peroneal tendon and the tendons in the medial aspect of the ankle, the tibialis posticus and the flexor hallucis longus. The treatment of choice is radical excision.[17]

Melanoma (See the section on Melanoma).—Adair and Pack[18] state that rarely the nail bed is the site of melanoma (Fig. 501). The thumb and the great toe are most frequently involved. The average age of patients with subungual melanoma is 9 years greater than that of patients with melanomas elsewhere.[19] They are less malignant than melanomas in other regions.

Pack and Adair[20] say: "The fully developed lesion is usually a black, fungating, well-demarcated ulcer, involving the nail sulcus and matrix and elevating the nail. The nail itself becomes thickened, brittle, split, and finally ulcerated. The melanoma sometimes has the appearance of purplish granulation tissue, flecked with small areas of scattered black pigment. A pathognomonic point in diagnosis is a border of coal black color which is nearly always present at the edge of the involved nail. An important point concerning the early gross appearance is the fact that the tumor [illegible]

in the skin surrounding the tumor. From the ulcerated surface a thin dark fluid exudes which stains the dressings and becomes brown, *like melanotic urine* on exposure to air. The local lesion is limited in the direct extension of its growth by the fascial planes of the distal [illegible] infections. The melanoma begins in the nail [illegible] the nail bed.

[illegible] al melanomas are of two types: (*a*) the fusiform spindle cells, the [illegible], intra- and extracellular pigment, *and infrequent* mitoses (the melanoma of this histologic variety is frequently called melanosarcoma); (*b*) the spherical, polygonal or epithelioid cells, often in sheets and pseudoalveolar arrangement, with less pigment and more frequent mitoses (the melanoma of this histologic variety is often termed melanocarcinoma). Regardless of the histologic picture and cell [illegible] way [illegible] ually [illegible] ctive



Fig. 501.—Subungual melanoma of the great toe. (Adair, F. E.; Pack, G. T., and Nicholson, M. E.: Bull. Assoc. franç. p. l'étude du cancer 19: 549, 1930.)

for twenty-eight years. The onset of true melanoma may be a slow insidious development, but once the tumor begins to grow and assert its malignant properties, the ensuing course may be fairly rapid. Pain is never conspicuous, even as a late symptom. . . .

"Once the diagnosis of subungual melanoma is made, amputation of the digit should be considered as an emergency, because the day or time of the metastases can never be foretold. The number of phalangeal joints to be sacrificed depends on the proximal extent of the tumor. Conservative surgical excision with preservation of the terminal phalanx is hazardous." Pack and Adair make a prophylactic dissection of the regional lymph nodes six weeks after amputation if no involvement is shown. If there is involvement, the dissection should be made one or two weeks after amputation.[21]

Kurtz[22] reported a case of pigmented mole of the sole of the foot which resulted in a fatal widespread melanotic sarcoma.

Osteoma.—*Exostosis of the Head of the Fifth Metatarsal.*—The lateral margin of the distal end of the fifth metatarsal when subjected to continuous pressure by tight shoes will occasionally develop into an exostosis which, after a period of time, may project as much as 1 cm. above the normal

surface of the bone. These exostoses are extremely painful. The treatment is the excision of the exostosis through a curved incision whose convexity is upward. This operation is usually best done with the patient under general anesthesia. Utmost care must be taken for the preservation of asepsis. After the overlying soft parts have been reflected, the exostosis itself is carefully removed with a rongeur or chisel.



Fig. 502.—Subungual exostosis. (Surgical Dispensary, Northwestern University Medical School. Courtesy of Dr. John A. Wolfer.)

Exostosis of Phalanges of the Little Toe.—A complication of corns is the formation of an exostosis of the lateral margins of the phalanges of the little toe. The exostosis is no doubt formed in response to the continued irritation from external pressure from a too tight shoe. The diagnosis of this condition is made by *x*-ray, and the treatment is surgical excision of the exostosis.[23]

Subungual Exostoses.—Exostoses of the distal phalanx of the great toe may develop beneath the nail (Fig. 502). The condition may be painful and may cause elevation of the nail. Kurtz[24] emphasizes the importance of an *x*-ray examination (Fig. 503) in all cases involving a painful tender toe.



Fig. 503.—Fully ossified subungual exostosis, clinically occupying most of nail bed (Kurtz, A. D · Am. J. Surg 16: 81, 1932.)

Lapidus[25] suggests a plastic operation for complete and permanent removal of the toe nail in cases of subungual osteoma and *onychogryposis* (thickened hypertrophied nails, Fig. 504). Removal of the exostosis after avulsion of the nail may bring about relief after a new nail has grown in. In many cases, however, it will be necessary to remove the nail bed as well, to prevent the formation of future nails.

Exostosis of the Os Calcis (Calcaneal Spurs).—Calcaneal spurs are osseous projections from the underside of the calcaneus (Fig. 505). They are often thought to be exclusively of gonorrheal origin. According to Lewin,[26] this is grossly wrong. They may occur in relation to focal infections with ordinary

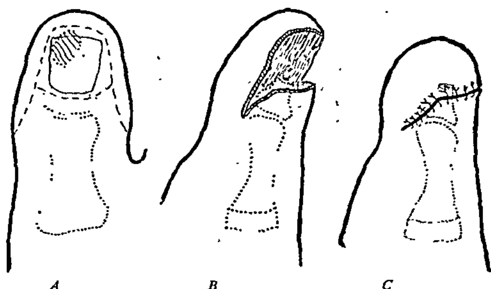


Fig. 504.—*A*, Interrupted line shows U-shaped skin incision. Note that base of dorsal flap is wider than its distal part because ends of U are extended in a slightly dorsiplantar direction. Dotted line represents outline of bones with subungual osteoma (lined obliquely); *B*, toe nail with its matrix completely removed and distal part of terminal phalanx resected, leaving a short dorsal and a long plantar flap; *C*, plantar and dorsal flaps are approximated and sutured together. (Lapidus, P. W.: Am. J. Surg. 19: 92, 1933.)

cocci, gonococci and spirochetes; with metabolic disturbances; with trauma; with static disturbances of the feet, and with a short plantar fascia. Von Lackum and Palomeque[27] reviewed 100 consecutive cases of exostosis of the os calcis at the Mayo Clinic "with the purpose of ascertaining how



Fig. 505.—Calcaneal spur.

frequently the gonococcus is a factor in the etiology of the disease." Their conclusions are as follows:

"Forty-four of 100 consecutive patients with calcaneal spurs gave a history of gonorrhea, and of these 40.8 per cent had definitely infected tonsils, 59 per cent had infected

teeth, and 22.2 per cent had definite prostatitis. Fifty-six patients did not give a history of gonorrhea; of these, 55.3 per cent had infected teeth, 20 per cent had infected tonsils, and 12.5 per cent had definite prostatitis. Eight patients without gonorrhea and 4 patients with gonorrhea had osteoarthritis of other joints. Syphilis, so far as could be ascertained, was not an etiologic factor in any of the cases.

"A variety of etiologic factors for calcaneal spurs have been commented on by various observers. Some factors, previously thought to be of primary importance, do not seem to be significant in the etiology. Neither syphilis nor gonorrhea is a gross factor in the etiology of most cases of calcaneal spurs. Foci of infection in the teeth, tonsils or prostate gland, and possibly other obscure areas, particularly those bearing streptococci are probably a large factor in cases in which multiple etiologic factors are present. The term 'gonorrheal spurs' is a misnomer and should not be used."

When there is pain, the patient should be put to bed with hot fomentations plus *Porter's lotion:*

	cc.
Tincture of opium	30
Diluted solution of lead subacetate	40
Tincture of arnica	50
Extract of hamamelis	60

Lewin's directions for the use of this lotion are as follows: "The entire foot and ankle are covered by four layers of gauze saturated with the lotion and enclosed in oiled silk or rubber sheeting. Hot fomentations of strips or pads of flannel are wrung out of hot water, about six layers wrapped around the impervious layer, and another sheet of oiled silk applied." A hot-water bottle or, better, an electric pad is placed at the side or under the foot and the whole is enclosed in a Turkish towel. In case operation is decided upon, a semilunar incision is made just below the insertion of the tendo achillis. The spur and some of the underlying attached bone are removed by chisel and mallet. This operation is not easy, and a good light and adequate assistance are essential. After the operation plaster casts are applied for a period of about ten days. Lewin's comment on this condion is very pertinent. "It is highly inadvisable to remove calcaneal spurs unless they are the cause of the patient's complaint, or unless one feels that removing the spur will give the patient a comfortable foot. The situation is analogous to operating on hallux valgus; after a perfect operation, the patient may still have painful feet due to conditions outside the big toe area, such as metatarsalgia." Jones and Lovett[28] report on a patient who had spurs of equal size under the os calcis of the feet but had pain in only one foot. Regan[29] suggests the following treatment for calcaneal spurs: "At the point of greatest tenderness an ordinary hypodermic needle was thrust through the skin on the plantar area of the os calcis until osseous tissue was reached. Then a few drops of 2 per cent procaine hydrochloride was injected, followed in a few moments by 0.5 cc. of sodium morrhuate in 5 per cent benzyl alcohol The relief from the symptoms was rapid as well as fairly well prolonged. Up to the present time thirty-three patients with painful heels due to a calcaneal spur have been treated in this manner, and of the thirty-three only two failed to obtain relief following the first injection; it was necessary in one case to perform four subsequent injections before relief was obtained. One patient has had no relief from this treatment. The relief obtained usually lasts for between two and three years, after which another injection may be given."

The instructions furnished by Tokmakow[30] are of value: "An incision curved upward is made on the lateral border of the plantar arch below the course of the sural nerve. The tendons of the peroneus longus and of the peroneus brevis muscles are not injured. After healing, the scar is located in a depression, in the region of the thin, easily movable skin, and thus it does not interfere during walking. The vascular nerve bundle, especially the external plantar artery with the like-named nerve, remains in the intermediate space between the muscles, and during the operation it is pulled downward. The intervention is done under local anesthesia and there is almost no bleeding."

In Chang and Miltner's[31] 5 cases there was a recurrence after operative treatment in 31.4 per cent.[32]

Kurtz[33] has reported an interesting case of exostosis of the anterior inferior portion of the os calcis in a child of 7 years .Recovery followed removal through an external lateral incision.

Corns (Clavus).—Corns are localized painful thickenings of the epidermis due to the continuous pressure of ill fitting shoes and may be extremely painful. A "*hard corn*" is a thickened, horny induration on the exposed part of the toe. A "*soft corn*" develops between the toes. Of the latter, McElvenny[34] describes two varieties: (*a*) the phalangeal joint corn, which presents on the side of the toe and has its counterpart on the adjacent toe, and (*b*) the phalangeal base corn, which is situated deep in the web between two toes and is "caused by a prominent phalangeal base of the proximal phalanx of one of the toes." Corns may become infected and suppurate. Properly fitting shoes and hosiery, circular protective corn plasters, paring of the upper layers of the corn with a safety razor blade and soaking the feet twice daily in soda bicarbonate solution (Vaughan and Burnham) will give relief or cure. Ring-shaped or oval protective pads are of value. Vaughan and Burnham[35] advise painting the corn night and morning for several days with the following mixture:

Extract of cannabis indica	0 6 Gm.
Salicylic acid	2.6 "
Collodion and flexible collodion, of each	8.0 cc.

At the end of this time the corn is scraped away or removed by soaking in hot water. Several courses of treatment may be necessary. The same plan of treatment may be carried out with the various proprietary corn remedies, most of which contain salicylic acid and collodion. Soft corns are treated by washing the feet twice daily in hot water and soap, sponging them with alcohol, and powdering with bismuth subnitrate, or borated talcum powder. A small piece of cotton between the toes will be useful. In the treatment of corns particular care must be taken for the preservation of asepsis. The hands, instrument and skin of the toe should be rendered as nearly sterile as possible before any surgical procedures are undertaken. Trustworthy chiropodists are generally the best ones to take care of corns, but one should know their qualifications before recommending them.

The operative treatment of corns has come into more favorable consideration. The skin between the fourth and fifth toes may be excised for troublesome corns (Ryerson), the exostosis or exostoses may be cut off (Christopher; McElvenny) or the fifth toe may be amputated when it is drawn up and pressed upon by the shoe.[36] Galland[37] believes a pathologic bursa and exostosis form the underlying cause of corns. He advises operative treatment.

Lapidus[38] says that since it is difficult to eliminate the pressure of the modern shoe, especially in the case of women, he has, in a number of cases of "soft corn," removed the projecting lateral part of the basal phalanx of the fourth toe with satisfactory results.

The operation is a simple one, performed under local anesthesia. There is no need for the patient to be hospitalized. It is extremely important, however, that the skin be treated for a few weeks prior to the operation in order that the often present ringworm infection may [illegible]

An [illegible]
meta[illegible]
The [illegible] and the lateral prominence of the basal phalanx is removed. (Fig. 506.) The capsule is closed with one stitch and one or two subcutaneous stitches are taken in order to obliterate the cavity usually created by the operation. The skin is sutured with a few stitches. The corn itself is not touched during the operation but normally falls off when the stitches are removed.

better than doctors, and they will take infinite pains to get the lead foil exactly in the right

Sisk[44] *says:* "The technic is a dose twice the time required to produce a mild erythema on the flexor surfaces, with unfiltered radiation limited to the bounds of the lesion, followed, if required, in three weeks by a dose of one and one-half erythema intensity." The greatest number of treatments in a single case was 5.[45]

When radium is used Valade[46] says "the flat application is the most popular method of applying radium: A half strength flat glazed element, application screened with 0.1 mm. aluminum, in contact with the wart for fifteen to thirty minutes or even longer if there is much hyperkeratosis."

Haggart[47] uses salicylated collodion (½ to 1 drachm of salicylic acid to the ounce of collodion), which is applied once or twice a day and allowed to dry. The treated area turns white and can be easily removed. In cases of severe plantar warts, he favors excision fol-



Fig 508.—Glomus tumor protruding beneath the nail of the right first toe. (Theis, F. V.: Arch. Surg. 34: 1, 1937.)

plantar wart. The surrounding skin should be protected with vaselin and the acid very carefully applied. Blair, Brown and Byars[49] say :"If the wart has not entirely disappeared a month or six weeks after a moderate dosage of radiation, one of two plans should be

ing skin and underlying fat have been spared. This has been our procedure of choice." Dickson[50] recommends the formidable "pie" operation in certain cases. This consists of wide excision of the wart with a toe and the corresponding metatarsal bone.

Ganglion. (See Ganglion under section on Tumors of the Upper Extremity.) —The presence of a ganglion on the lower extremity is unusual. It is occasionally found in relation to the extensor tendons of the foot. The author has excised a large ganglion from the popliteal space.[51] Fifteen similar cases were reported by Meyerding and Van Demark,[52] to which they applied the following synonyms: posterior hernia of the knee, baker's cyst, popliteal cyst, semimembranosus bursitis, medial gastrocnemius bursitis and popliteal

bursitis. The treatment of ganglion of the lower extremity is identical with that of ganglion of the upper extremity.[53]

Xanthoma.—Xanthoma of the Achilles tendon has been described by Young and Harris.[54]

Glomus Tumor of the Toe. (*See the section on Glomus Tumors.*)—Theis[55] reported a glomus tumor of the big toe (Fig. 508) in a case of senile arteriosclerotic circulatory disease. Complete relief of pain was obtained by local excision of the glomus tumor. I have cured a glomus tumor of the great toe by simple excision of the tumor. The diagnosis was made on the clinical findings and was verified microscopically.

Synovial Cyst of the Popliteal Space (Baker's Cyst).—Haggart[56] says: "Synovial cysts of the popliteal space are due to a posterior herniation of the knee joint capsule or to hyperplasia—'fluid distention'—of one of the adjacent bursae, most frequently the semimembranosus bursa." Usually there is a history of trauma, and the symptoms often suggest internal derangement of the knee joint. Haggart[5] points out that "unless the popliteal space is examined carefully the presence of such a cyst may well be missed." The treatment is excision. He removed 35 cysts, with 1 recurrence.

Neurofibroma.—Neurofibroma of the foot in an eleven year old girl is reported by Hauser.[58]

CONGENITAL AND ACCQUIRED DEFORMITIES

Syndactylism, Polydactylism and Gigantism.—Syndactylism occasionally occurs on the foot, but, because of the concealment of the latter by the shoe, operative treatment rarely will be necessary. Should operation, however, be



Fig. 509.—Os subcalcis. (Milliken, R. A.: *Am. J. Surg. 37: 116. 1937.*)

indicated it will be done along the lines previously described in respect to syndactylism of the hand.

Polydactylism or supernumerary digits will require amputation of the offending digit in order to facilitate shoe fitting in later life. This amputation is best done very soon after birth, in accordance with the methods described

previously. Operation should be preceded by *x*-ray examination to determine the least useful digit. Mayer and Sashin[59] report a case of supernumerary foot successfully removed by operation. Congenital absence of one or both legs may occur.[60] Thomas[61] reports an interesting case of partial gigantism involving the toes which was corrected by amputation and plastic repair of the foot.

Abnormalities of the Bones and Joints.—*Incon*...
of the Foot.—A very ...
and Lapidus.[62] The ... changes due to the

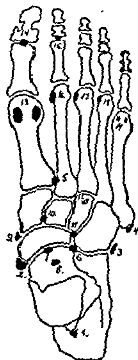


Fig. 510.—Diagrammatic ground plan of the inconstant bones and sesamoids of the foot: 1, *Os trigonum*; 2, accessory scaphoid; 3, *os peroneum*; 4 *styloid epiphysis* and location of the disputed os vesali... calcaneus secundaris; 7, os ... and 19, incon-s... sesamoids of the ... the fifth toe represents the not unco... into one solid piece. (Burman, M. S., a... Surg. 22: 936, 1931.)

... become ... in view of the fact that about ... of feet present such anomalies. The inconstant bones seldom disturb the statics of the foot." Burman and Lapidus studied 1000 roentgenograms of the foot. The inconstant bones and sesamoids which are fully discussed by them are shown in figure 510. For the details the reader is referred to the original article. Milliken[63] reported a case of os subcalcis (Fig. 509) which caused sharp pain in the heel. Cure followed excision. Supernumerary tarsal scaphoids have been reported by Cravener and MacElroy[64] and

bipartite tarsal navicular by Volk.[65] Fracture of the os peroneum has been reported by Ginieys.[66]

Bipartite Patella.—A case of bipartite patella is reported by Neviaser,[67] who also reviewed the literature on this subject. This author states that the



Fig. 511.—Os vesalianum pedis. (Davis, G. S.: Am. J. Roentgenol. 17: 551, 1927.)

anomaly is usually incorrectly reported as a fracture. It is nearly always bilateral and "is always in the upper and outer quadrant of the patella" (Neviaser), where fracture rarely occurs. "The history and physical finding are rarely those of a fractured patella." (Neviaser)



Fig. 512.—Tripartite calcaneal epiphysis.

Tripartite Calcaneal Epiphysis.—According to Ruckensteiner[68] this condition is not uncommon at the age of 8 to 9 years (Fig. 512). It is possible that this condition may be a form of osteochondritis (see section on Osteochondritis).

Bifid Os Calcis.—Sever[69] reported 3 cases of bifid os calcis and emphasized the importance of distinguishing this condition from fractures. He believes that the condition disappears by the age of 3 years.

Twisted Nail (Onychogryposis).—Many cases of twisted or deformed nails are remedied by simple avulsion of the toe nail, and this expedient always should be tried first. Where the second nail is not an improvement there should not only be an avulsion of the nail but the removal of the entire nail bed to prevent further regeneration of the nail. (See the section on Subungual Exostosis.)

Hammer toe is a condition which most frequently involves the second toe, and in which there is an extension (dorsal flexion) of the proximal phalanx of the toe. The second and distal phalanges are flexed, and a clawlike appearance results. The interphalangeal joint between the proximal and the second phalanx is elevated and may be the site of painful keratosis. The treatment of this condition is entirely surgical. For simple hammer toe, *tenotomy of the extensor tendon will bring relief which may be permanent.* In the more severe conditions, the tenotomy must be supplemented by a V-shaped excision of the prominent joint, with subsequent realignment of the phalanges. This rather formidable operation is often less advisable than the method which consists of amputation of the toe. The foot is not materially weakened by amputation of the second toe, and complete relief generally is obtained.

Lapidus[70] obtained good results in 26 out of 30 cases with the following operation: "Under local block anaesthesia, a hockey-stick skin incision is made on the dorsum of the toe, somewhat laterally from the middle line, care being taken to spare the dorsal digital nerves and blood vessels. No tourniquet is used. The flattened tendinous expansion of the extensors, which is intimately interwoven with the joint capsule, is exposed. A tongue-shaped flap, with the base attached to the middle phalanx, is outlined over the dorsum of the proximal interphalangeal joint, and the latter is exposed. A small dorsal prominence over the dorsum of the head of the proximal phalanx sometimes requires shaving off. A subcutaneous plantar tenotomy and capsulotomy of about 180 degrees—that is, from one collateral ligament to another—are performed. The tenotome is held close to the bone avoiding digital blood vessels and nerves. It is important to obtain complete release and even slight overcorrection of the plantar-flexion contracture. The tongue-shaped flap is *then resutured with reduplication (as in a double-breasted coat) to the proximal stump of* the tendon and capsule by means of one or two fine chromic mattress stitches. If dorsiflexion contracture is present at the metatarsophalangeal joint, it is also released subcutaneously with a tenotomy knife in the thorough manner already described. Extreme gentleness during the operation and meticulous care of circulation should be exercised.

"The toe is splinted with well-fitted, loosely strapped whale bones. Immobilization should be thoroughly carried out for about three or four weeks after the operation. The patient may be permitted to walk a few days after the operation, wearing shoes cut out over the toes." For the treatment of more difficult cases, see Lapidus' original article.

Selig[71] has operated successfully on 20 hammer toes without the development of infection by the following method: "Local or general anesthesia may be used, according to the indications. If local anesthesia is used, it is unwise to use a tourniquet about the base of the toe because of the remote possibility of gangrene following the combination of local anesthesia and a tourniquet as described by Garlock.

"Through a medial longitudinal incision over the proximal interphalangeal joint the articulation is exposed. A transverse *incision may be used if desired and is especially satis*factory if a heavy corn is present over the joint, as this can then be excised by an elliptical transverse incision. Theoretically, the longitudinal incision is less likely to interfere with the blood supply of the toe, but in many toe operations for other conditions I have seen no circulatory disturbances following a transverse incision. No circulatory difficulties occurred in the present series of cases in which the average age was 38 years and varied

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should be removed from the proximal phalanx. Remove merely enough bone to obtain
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of the distal joint can be corrected by manual stretching. A Kirschner wire, .../1000 of an
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pliers must be used to fasten the wire in the chuck or it will tend to rotate in the chuck rather than penetrate the bone. It takes some practice to insert this wire correctly even under direct vision, and if the point of the wire does not appear approximately in the center of the denuded surface of the middle phalanx, another attempt should be made. In some cases three or four attempts were necessary before the wire was properly centered. No ill effects followed the multiple passages of the wire, and motion in the distal inter-phalangeal joint was only slightly or not at all impaired after the withdrawal of the wire 6 weeks later. If the point of the wire appears at the denuded proximal surface of the middle phalanx,

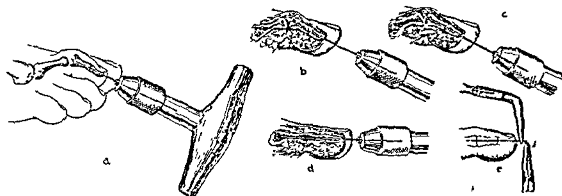


Fig. 513.—*a*, Schematic drawing of the wire, the chuck and its method of insertion after the proximal interphalangeal joint has been resected; *b* to *e*, subsequent steps in the operation. (Selig, S.: Surg., Gynec. & Obst. 72: 101, 1941.)

the chuck is carefully released with the aid of pliers to avoid the inadvertent disturbance or withdrawal of the inserted wire. An additional length of wire, corresponding to two-thirds of the length of the proximal phalanx, is now permitted to extend from the chuck. The length of the average adult proximal phalanx of the second toe is between 1 inch and 1¼ inches. Therefore, if approximately 11/16 of an inch of wire is inserted into the proximal phalanx, sufficient immobilization is obtained, and there is no danger of crossing the metatarsophalangeal joint. If the operation is carried out on the other toes, the surgeon must, by clinical and *x*-ray measurements, estimate the length of wire to be inserted into the proximal phalanx (Fig. 513*b*).

"Carefully, to avoid disturbing the partially inserted wire, the chuck is again tightened with pliers, and the point of the exposed wire is then carefully placed at the center point of the denuded distal surface of the proximal phalanx (Fig. 513*c*). This position of the point of the wire is maintained, the deformity is corrected, and the wire is driven longitudinally through the proximal phalanx by the same rotary motion of the chuck (Fig. 513*d*). If, by any chance, the wire is not centrally placed in the proximal phalanx, it should be carefully withdrawn until the point again protrudes from the middle phalanx, and the procedure repeated. If the operator is satisfied that the wire has been satisfactorily driven, the resected joint should be inspected. The joint must be flush and the two phalanges firmly fixed to one another without any intervening space. If motion between the two phalanges can be demonstrated, one can be certain that the wire has not been properly placed. By means of two small right angle pliers the projecting end of the wire should be carefully bent to a right

angle and the excess wire cut off (Fig. 513*e*). This last step is to prevent the possibility of the wire wandering deeply into the tissues. I have experienced no wandering of the wires except in those cases in which the wire inadvertently crossed the metatarsophalangeal joint. A small longitudinal strip of gauze is now placed over the wound, extending around the end of the toe to the plantar surface, and the projecting end of the wire is permitted to extend through the gauze. Collodion is used to fasten the gauze to the skin, and no further dressing is necessary except two small strips of adhesive over the projecting end of the wire to prevent its catching in objects. It is wise, at first, to have an *x*-ray check-up before the patient is discharged. If the *x*-ray examination shows that wire has been satisfactorily placed, the patient may be discharged immediately to resume normal activities with the use of a cut-out shoe. If no pain or temperature occurs, the wire and the sutures may be removed at the same time, in 6 weeks. If pain or swelling occurs, the wound should be inspected, at which time the sutures can be withdrawn. In the series thus far there have been no infections. In four toes there was a slight serous discharge about the wire which was somewhat loose. In 2 of these cases the wire had been permitted to cross the metatarsophalangeal joint, and I think the resultant motion of the wire when the patient walked caused the serous discharge. The wounds rapidly closed as soon as the wire had been withdrawn."[72]

Hallux valgus is a bony deformity of the foot in the region of the first metatarsophalangeal joint in which the phalanges of the great toe are deflected laterally. In cases of extreme deformity, the great toe may lie over or under the second toe. Complications of this deflection are the formation of an exostosis at the lateral border of the distal end of the first metatarsal and an inflamed adventitious bursa over this exostosis (*bunion*). The cause is probably the wearing of too narrow or too pointed shoes, although many who wear such shoes do not acquire bunions and hallux valgus. The prophylactic treatment and the treatment of mild disorders are directed toward wearing the proper shoes. The curative treatment is surgical.

Operative Treatment of Bunion and Hallux Valgus.—Many types of operation have been devised, and all of them are most advantageously performed under general anesthesia. Some authorities, however, prefer local nerve block anesthesia. The large majority of bunions and the lesser grades of hallux valgus may be cured by the following simple operation: A curved incision is made with the convexity upward so as to encircle the bunion. The upward convexity is chosen so as to avoid a possible painful plantar scar. The flap is reflected downward and the adventitious bursa excised. With a straight saw the exostosis at the distal end of the first metatarsal bone is then sawed off so as to leave a straight lateral surface on the metatarsal bone. The exostosis also may be removed with a rongeur or a chisel. After the gross removal of the exostosis, the base is made smooth with a coarse rasp, such as that designed by Putti. The flap is then replaced, and sutured with a few interrupted sutures. The extensor tendon of the great toe is then subjected to tenotomy, with a small incision opposite the metatarsophalangeal joint. This tenotomy is very simply accomplished by flexing the toe dorsally and by grasping through the skin the extensor tendon of the great toe. The tenotome is then forced through the skin beneath the tendon, which is steadied by the other hand. The sharp edge of the tenotome is held upward. The tendon is severed with a gentle sawing motion, care being taken not to cut too far upward and buttonhole the skin. The completion of the tenotomy is evidenced by the easy plantar flexion of the toe. The purpose of the tenotomy of the extensor tendon is to remove the lateral pull on the deflected great toe, which has served only to increase the deflection. All wounds are carefully dressed. A very useful dressing to preserve asepsis is gauze saturated in

compound tincture of benzoin. A pad is placed between the great toe and the second toe, and the entire foot is encased in dressings. The patient is encouraged to move the great toe on the fifth or sixth day, but weight bearing is not permitted for ten to fourteen days. McElvenny and Thompson[73] report that 77 of 100 patients were entirely relieved of bunion pain after simple exostosectomy. Other operations which have been devised for the cure of bunion include lateral cuneiform osteotomy of the first metatarsal bone (the purpose of which is to correct the deflection of the phalanges) and the Mayo operation, which consists essentially of the resection of the head of the first metatarsal bone and the introduction into the space so formed of the adventitious bursa, which is left attached to one border and sutured with catgut into the depths of the wound.

McBride[74] has devised a conservative operation for bunions (Fig. 514). An incision 2 inches in length is made along the external border of the extensor hallucis longus with its center over the joint. By dissecting close to the metatarsal head, the conjoined tendon

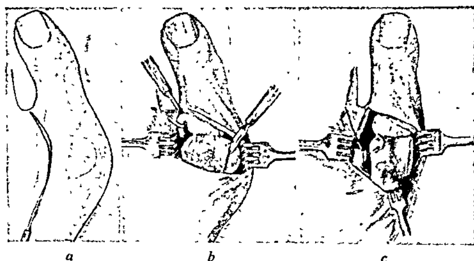


Fig. 514.—*a*, Incision slightly curved laterally to tendon of the extensor hallucis longus. *b*, The conjoined tendon of the transverse and oblique heads of the adductor hallucis and the flexor hallucis brevis are exposed and severed from their attachments. The exostosis is exposed through the same incision. *c*, Transplanting the conjoined tendon into the head of the metatarsal. The prominence of the metatarsal head has been removed. (McBride, E. D.: J. Bone & Joint Surg 10: 735, 1928)

of the adductor hallucis group is exposed and severed from its insertion. The conjoined tendon of the adductor muscles and the external head of the flexor hallucis brevis are transplanted into the dorsum of the head of the first metartarsal bone. The bursa is dissected out, and the bony prominence of the inner side of the metatarsal head is chiseled off. The toe is manipulated into slight overcorrection, and a plaster slipper is applied and kept on for seven to ten days. Weight bearing is allowed at the end of two weeks, but the toe should be held in correction by adhesive plaster for four to six weeks. Kreuscher and Kelikian[75] remove the sesamoid bones in their entirety. The removal of the proximal two thirds of the proximal phalanx of the great toe, together with the exostosis, is recommended by Galland and Jordan.[76] Correction of hallux valgus by metatarsal osteotomy has been

to previously. They

the insertion of the

plantar fascia in the os calcis. Calcaneal spurs are rarely painful. Cozen[78] has had success

talipes valgus is the everted and abducted foot. *Over 75 per cent of congenital clubfeet* are of the equinovarus variety, and about 5 per cent are of the valgus variety. In talipes equinovarus the deformity consists of inversion of the whole foot, abduction of the forefoot and plantar flexion. The condition may be slight or so severe that the sole faces almost upward. (Jones and Lovett) If the condition is untreated the patient will reach adult life with a most awkward gait in which he walks on the outside of his foot. "The foot cannot be overcorrected by the examining hand and, from infancy on, the deformity will increase in the untreated cases." (Jones and Lovett) The treatment consists in maintaining the foot in the overcorrected position of marked dorsal flexion, marked eversion and marked abduction until the bone has become reshaped and the ligaments and muscles have adjusted themselves to their environment and requirements. The treatment should be started as early in life as possible. "*In very young children, it is probable that every case can be cured without* operation, with the exception of a possible tenotomy of the tendo achillis in the final stage,

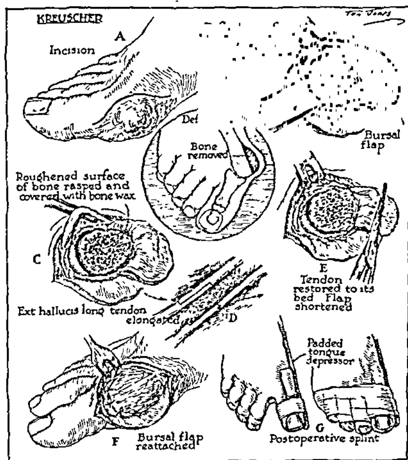


Fig. 515.—Kreuscher operation for bunions. (By permission of Johnson & Johnson)

... The ... rsion, ... pable of being placed in the overcorrected position without encountering resistance. Having reached this point it is only necessary to see that the contraction does not return by the use of less frequent manipulations."[79]

Foot Strain and Flatfoot.—There is no type of arch which may be called normal. *According to Hoffman,*[80] *the height and strength of the arch are* of no value in estimating the strength or usefulness of the foot, and normal feet present high, medium and low arches, in nearly the same proportion as do feet with weakened arches. The abducted and everted feet are probably more liable to foot strain than other feet.[81]

The symptoms of *foot strain* include local stiffness and lameness, which are most marked on getting up in the morning and after an active day; and pain and tenderness under the tubercle of the scaphoid, below the internal malleolus, along the ridge of the astragalocalcaneal joint and running down to the inner side of the os calcis. The gait is peculiar in that raising the heel is avoided. There may be synovitis of the knees, backache, and cramps in the soles of the feet and in the calves of the leg. Callosities may be present under the second and third metatarsal heads, which may extend to the inner border of the foot and back to the heel. *Acute painful foot* is seen in active young children and in persons, for instance nurses, who are on their feet a great deal. A preceding illness favors the condition. The treatment is rest in bed with hot foot baths. As the tenderness diminishes, massage and baking are given. The foot is strapped with adhesive plaster in a position of inversion



Fig. 516.—Imprint of a normal foot and of moderate and marked flatfoot. (Kurtzahn, H.: Kleine Chirurgie, Berlin, Urban & Schwartzenberg, 1929.)

and abduction. The strapping starts at the outer border of the foot and passes under the arch and half way up the leg to the knee. "In the very acute cases it is well to apply, under the strapping, a pad of felt filling the arch of the foot. Weight-bearing exercises as a therapeutical measure are not advised until the acute stage is over, but active nonweight-bearing exercises may be begun as soon as they may be given without pain. In either type the exercises are to be given to cultivate abduction and inversion of the foot." (Jones and Lovett)

Flatfoot may be congenital or acquired and is not necessarily painful. Acquired flatfoot is of two types, the flexible and the rigid. The general principles of treatment of flexible flatfoot, according to Jones and Lovett, are as follows: (*a*) If excessive weight is present, the weight should be reduced if possible. (*b*) If the general condition is poor, and the muscles consequently lax, the condition should be improved. (*c*) If overuse preceded the strain, such overuse should be avoided as far as possible. (*d*) If the patients are

children, and are suffering from overwork and rapid growth, a remedy of these conditions and a cutting down of activity are indicated. (*e*) If due to unusually bad shoes, better shoes should be worn. (*f*) Mechanical defects of the feet should be sought for, identified if present, and, as far as possible, compensated. An extremely important measure in the treatment in these cases is the raising of the heel of the shoe by a wedge ¼ to ⅓ inch on the inner side, sloping to zero on the outer side and, if necessary, the placing of a small wedge on the sole just behind the head of the first metatarsal bone. This tilts the foot outward in walking and tends to make the patient toe inward. Reed[82] emphasizes that the wedge should be placed between the heel and the posterior end of the sole, "directly below the rand." Placing the wedge below the heel, especially in women's shoes, makes a "leaning tower" and improper strain.

When barefooted, these patients should walk on their toes. They should strive to learn to walk with the toes pointing directly forward. Contrast baths *and a strap of adhesive tape around the scaphoid bone are useful adjuncts.* Exercises to abduct and invert the foot should be given. With proper shoes the patient should rise on tiptoe and come down on the outer side of his foot. The sole of the shoe should be stiffened in the shank by the insertion of a flat piece of metal. Jones and Lovett are of the opinion that only the very exceptional patient will require foot plates and that these must be of the double flange variety. In *rigid flatfoot manipulation under anesthesia with* the Thomas wrench and immobilization in plaster of paris will be necessary. In young children, in addition to the crooked heel, a sloping felt pad may be worn on the inside of the shoe which supports the arch on the inner side of the foot. It may run from the base of the first metatarsal bone to the front of the os calcis.[83]

Minimus Digitus Varus.—According to Gottlieb,[84] "The deviation of the little toe toward the midline of the foot and the prominent head of the fifth metatarsal can be overcome by methods similar to those outlined for hallux valgus.

[illegible]

"For the operative correction of the minimus digitus varus two methods are advocated. One is as follows: A part of the head of the metatarsal and, if need be, a portion of the third phalanx are chiseled off, thus removing the offending prominence which makes the forefoot too wide. Capsulotomy and tenotomy may have to be added if the toe is dorsally flexed and contracted.

"The other operation is to perform an osteotomy of the fifth metatarsal shaft and to shift the distal portion to the midline of the foot. In this corrected position the metatarsal unites. I have obtained the best *results by the former method which is simple and effective.*"

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children, and are suffering from overwork and rapid growth, a remedy of these conditions and a cutting down of activity are indicated. (*e*) If due to unusually bad shoes, better shoes should be worn. (*f*) Mechanical defects of the feet should be sought for, identified if present, and, as far as possible, compensated. An extremely important measure in the treatment in these cases is the raising of the heel of the shoe by a wedge $\frac{1}{4}$ to $\frac{1}{8}$ inch on the inner side, sloping to zero on the outer side and, if necessary, the placing of a small wedge on the sole just behind the head of the first metatarsal bone. This tilts the foot outward in walking and tends to make the patient toe inward. Reed[82] emphasizes that the wedge should be placed between the heel and the posterior end of the sole, "directly below the rand." Placing the wedge below the heel, especially in women's shoes, makes a "leaning tower" and improper strain.

When barefooted, these patients should walk on their toes. They should strive to learn to walk with the toes pointing directly forward. Contrast baths and a strap of adhesive tape around the scaphoid bone are useful adjuncts. Exercises to abduct and invert the foot should be given. With proper shoes the patient should rise on tiptoe and come down on the outer side of his foot. The sole of the shoe should be stiffened in the shank by the insertion of a flat piece of metal. Jones and Lovett are of the opinion that only the very exceptional patient will require foot plates and that these must be of the double flange variety. In rigid flatfoot manipulation under anesthesia with the Thomas wrench and immobilization in plaster of paris will be necessary. In young children, in addition to the crooked heel, a sloping felt pad may be worn on the inside of the shoe which supports the arch on the inner side of the foot. It may run from the base of the first metatarsal bone to the front of the os calcis.[83]

Minimus Digitus Varus.—According to Gottlieb,[84] "The deviation of the little toe toward the midline of the foot and the prominent head of the fifth metatarsal can be overcome by methods similar to those outlined for hallux valgus.

"The conservative treatment is practically the same only that the strapping and splinting of the little toe differ from those of the big toe. These measures may suffice if the condition has not advanced too far: if the toe has not become permanently fixed in the malformed position by contractures of the joint capsule and the tendon of the dorsal flexor.

[illegible]

forefoot too wide. Capsulotomy and tenotomy may have to be added if the toe is dorsally flexed and contracted.

"The other operation is to perform an osteotomy of the fifth metatarsal shaft and to *shift the distal portion to the midline of the foot.* In this corrected position the metatarsal unites. I have obtained the best results by the former method which is simple and effective."

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CHAPTER XXIII

MINOR SURGICAL TECHNIC

LOCAL ANESTHESIA

De Takáts[1] has furnished some valuable suggestions pertaining to local anesthesia. In discussing the contraindications for the use of local anesthesia, he says that children under 14 years of age and certain nervous, irritable or mentally disabled patients are not suitable subjects. Tact and proper premedication will reduce the size of this group. Inflamed tissue never should be injected locally. "There is no objection, however, to performing distant nerve blocks for local inflammatory conditions." In cases of generalized infection and in too complicated operations, such as radical amputation of the breast, local anesthesia is inadvisable. Koch and others emphatically advise against the use of local anesthesia in or near infected tissues. Lambert and Snyers[2] believe it to be contraindicated in finger infections.

On the other hand, the opinion of Ádám[3] will carry weight. This author, professor of surgery at the University of Budapest, reports 31,797 operations performed under local anesthesia *without a single fatality during operation*, and 8,000 were operations on outpatients. Ádám says: "Many surgeons are disinclined to employ local anesthesia in inflammatory conditions because they fear that forcing the solution into the tense tissue may cause pain; they are afraid also that infective matter may be conveyed into healthy tissues, and give rise to spreading infection. I never have been restrained by inflamed tissues, from operating under local anesthesia and I never saw any unfortunate consequence. Of course, if the field is of small size, I prefer circular infiltration in the healthy tissues or I

tration of inflamed tissues never caused spreading of the infection; it has rather tended toward quicker amelioration or even subsidence of the inflammation, possibly by abolishing pain. Of course I readily admit that there are cases in which a superficial ethyl chloride inhalation is to be preferred to a more complicated local anesthesia (*e. g.*, mastitis and so on)." Wolfsohn[4] says: "The fear most surgeons have of using local anesthesia in the vicinity

to be used. Some

definitely inhibits

De Takáts lists the following advantages in the use of local anesthesia: (1) The diminution of postoperative pulmonary complications. (2) Avoidance of functional impairment in heart, liver and kidneys. (3) Diminution in paralyses of the gastrointestinal tract and the bladder. (4) Diminution of surgical shock. (5) Ability to have the active cooperation of the patient, as in operations upon the thyroid, etc.

Procaine (novocain) is the most generally suitable drug to use as a local anesthetic. De Takáts says that "it is safest, whether in office work or in large hospitals, to prepare the solution from tablets that contain novocain, or tutocain with some adrenalin in compressed form. Most of these tablets contain 0.00012 Gm. of synthetic suprarenin. Four of such tablets dissolved in 100 cc. of the solvent give a 0.5 per cent solution. This is the concentration most frequently used for infiltration; for nerve block a 2 per cent solution is the best." This author considers the following solution the best solvent:

Sodii Chloridi	7 Gm.
[illegible]	4 "
[illegible]	1,000 cc.
[illegible]	3 gtt.

This solution, together with the dissolved novocain, gives an isotonic concentration. The solution is sterilized in a water bath for fifteen minutes or

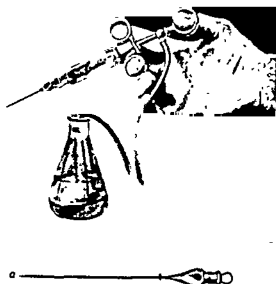


Fig. 517.—Sana-Lok Pitkin syringe for the administration of a local anesthetic: *a*, needle with security stop used in connection with the syringe. (Courtesy of Becton, Dickinson & Co.)

is autoclaved. If it is reddish brown it should be discarded. If the novocain solution is prepared from tablets which contain no adrenalin, 10 drops (3 drops in thyroid work) of a 1:1,000 solution should be added to every 100 cc. of solution. The solution should be freshly prepared.

It is now possible to obtain commercially ampules of novocain of different strengths and amounts and either with or without adrenalin or ephedrine. The adrenalin prolongs the anesthesia but should not, according to Pitkin,[7] be used in a patient with hyperthyroidism; here ephedrine should be used. Intravenous injection will cause toxic symptoms, sudden pallor, rapid pulse and a fall in blood pressure (de Takáts).

The quantities of solution of novocain which should not be exceeded are: 250 cc. of a 0.5 per cent solution, 100 cc. of a 1 per cent and 40 cc. of a 2 per cent. Pitkin[7] states that he, as well as Babcock, Farr, Lowsley and Jones,

have repeatedly used 400 to 500 and even 600 cc. of a 1 per cent novocain solution without causing untoward effects, and in none of the cases were toxic symptoms observed.

A preoperative hypodermic injection of morphine, $\frac{1}{6}$ or $\frac{1}{4}$ grain, and occasionally of scopolamine, $\frac{1}{200}$ grain, is proper as a preliminary to formidable operations, but premedication is unnecessary in most minor procedures. The use of the latter drug is not entirely without danger. Record or Luer syringes provided with different lengths and calibers of sharp needles will be employed. A 27-gauge hypodermic needle with a short bevel is generally best for minor surgical procedures. De Takáts wisely advises sterilizing the



Fig. 518.—Needle being guided around frontal bone by finger tips of left hand. Insert shows method of anesthetizing entire frontal region from primary central wheal. (Pitkin G. W.: Am. J. Surg. 8: 239, 1930.)

needles and syringes by dry sterilization or boiling in distilled water. A useful syringe for the administration of a local anesthetic is the self-filling, continous-flow type (Fig. 517).*

A large number of minor operations and the care of a great many injuries now may be effected in the office or outpatient department by the use of local anesthesia. Farr[8] says: "A most important dictum is that no patient should be given novocain by injection while in the upright position, provided the drug can be administered with the patient reclining. Also if the drug is injected with the patient in the upright position, facilities should be at hand

* This syringe is furnished by Becton, Dickinson and Co., under the name of "Sana-Lok Pitkin syringe."

to allow the assumption of the prone position without the slightest delay. So-called 'idiosyncrasies' to novocain, while extremely rare, probably do exist and as patients not infrequently faint from other causes, which produce cerebral anemia, the treatment of both conditions demands the prone or inverted position."

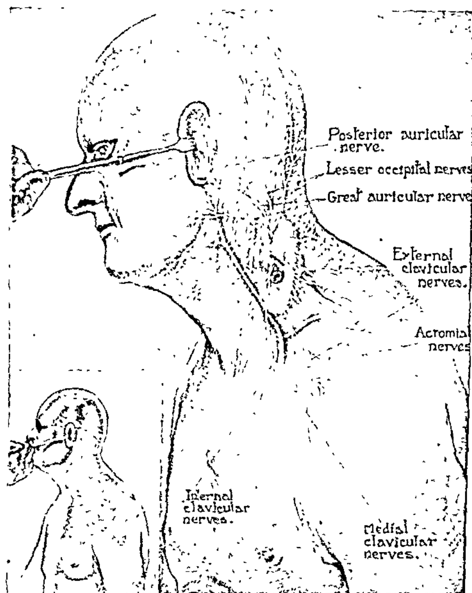


Fig 519.—Ten cubic centimeters of a 1 per cent novocain solution is injected under posterior border of sternocleidomastoid muscles, to anesthetize branches of superficial cervical plexus. Cutaneous field of anesthesia is shown in insert. (Pitkin, G. W.: Am. J. Surg. 8:239, 1930.)

The region to be operated upon may be rendered anesthetic by (*a*) blocking off the sensory nerves at some little distance from it ("*nerve blocking,*" conduction anesthesia), or by (*b*) blocking nerve endings in the region itself (*infiltration*). The injection is commenced by making a small wheal (about 1.5 cm. in diameter) in the skin by means of a short, fine caliber needle and the injection of a few drops of the solution.

Pitkin[7] says: "The wheal may be made with little or no pain and anesthesia is produced instantaneously. It is rarely ever necessary to raise more than one intradermal wheal for a field. Should subsequent wheals be desired raise them subdermally. Never attempt to produce an intradermal wheal on the plantar surface of the feet, the palmar side of the hand, or the scalp. Subcutaneous wheals may be made several inches from the original wheal (Fig. 518) by the use of 4-, 5- or 6-inch needles. If these are to be continued over a greater distance than the length of the needle a subdermal wheal may be raised by pressing the skin with the finger in advance of the needle to penetrate the skin from within. The



Fig. 520.—To anesthetize mental nerve one should endeavor to visualize location of needle point. Foramen is usually found midway between alveolar processes and lower border of jaw, over apex of second bicuspid. Shaded portion of insert shows field of anesthesia. (Pitkin, G. W.: Am. J Surg. 8: 239, 1930.)

flexible needles advocated will permit one to carry the subcutaneous wheal about the arm or leg from the site of the initial insertion, thus anesthetizing [illegible]

[illegible] insert a needle for deep injections unless it is attached to the syringe as this is an extremely painful manipulation. When a needle is introduced into the tissues project the solution ahead of the needle as it advances. This

procedure will not cause pain. Do not insert the needle and inject the solution in such a manner that it will infiltrate the tissues about the side of the needle, as this will not elimi-

first phalanx. The patient's finger is held by the operator as shown in Fig. 260. The skin and wheal over the base of the finger are pushed outward by the thumb, 2 to 3 cc. of solution

phalanx. Care should be taken not to inject too much solution as this may produce a constriction about the finger and impair circulation. If the tissues are too much edematized

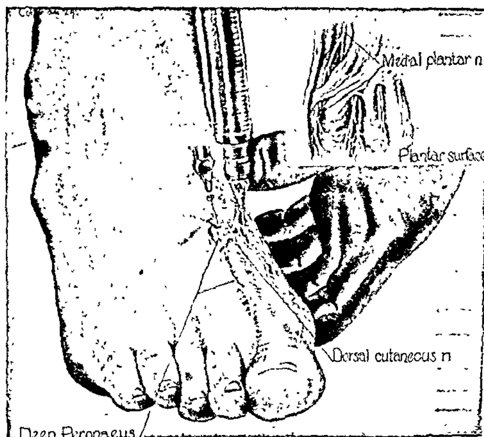


Fig. 521.—Method of anesthetizing tissues about first metatarsal bone for bunion operation. Note position of operator's fingers on sole of foot. Insert shows relation of needle points to plantar nerves, as needle approaches sole of foot. (Pitkin, G. W.: Am. J. Surg. 8: 239, 1930.)

or if too great a constriction is produced, necrosis of the tissues may be produced. When injections are made around or about a bone the bevel of the needle should be in apposition to the bone. If the point of the needle is directed toward the bone it may penetrate the periosteum or catch in the bone, bend or break the point, or possibly break the needle (See the important section on Traumatic Amputation of the Fingers)

"The technic for anesthetizing a single toe is as simple as anesthetizing a finger. The great toe, due to its size, necessitates the raising of two wheals internal and external to the tendon (extensor hallucis longus). Two to 3 cc. of a 1 per cent novocain solution are injected on each side of the phalanx. The other toes may be anesthetized from a single wheal raised on the dorsal surface."[9]

Seeger[10] says that up to 1932 the literature reports 64 cases of death due to novocain. In 23 the anesthesia was induced for tonsillectomy. Seeger

concludes that the reported deaths occurring during anesthesia of the throat were caused not by novocain poisoning but by a disturbance of the sinus caroticus reflex. Sonntag[11] says that "local anesthesia has a number of advantages over general anesthesia for the practitioner. However, it is associated with certain dangers and is capable of causing certain injuries which are not as well known as they should be and must be guarded against by the physician. These dangers and injuries are due to three important causes: (1) poisoning, (2) tissue injury, and (3) infection."[12] Organe[13] reports fatal convulsions following the injection of 1:1000 nupercaine.

In commenting upon gangrene of the toes following the use of local anesthesia Stark[14] considers the gangrene not so much the result of the particular anesthetic but due to the tenseness of the tissue; he therefore follows the intervention by vigorous massage of the toes or fingers until the [illegible]nesness has disappeared. This massage is painless, for as soon as it becomes painful the object of the massage is attained. Serafin[15] reports necrosis and [illegible] btained by using [illegible] epinephrine per [illegible] eports 4 cases of [illegible]

desired. Hauke[17] reports necrosis of two fingertips due to the local anesthetic used in operating for Dupuytren contracture. Gangrene of a finger following digital nerve block anesthesia has been reported by McLauglin[18] and also by Kaufman.[19] The latter stresses the importance of avoiding the use of epinephrine and a tourniquet. Gangrene of a toe following the use of local anesthesia is reported by Pelner.[20]

Farr[8] says: "In our experience, ether is the most satisfactory antidote to novocain. Caffeine is recommended but the few slight reactions we have seen subsided before this drug could be administered. It is our opinion that ether should be at hand and administered at once in case a patient shows a serious reaction. Caffeine, when used, should be given intravenously and in large dose, 7 grains. These drugs are as much a part of the necessary equipment as are syringes and should be in readiness before the local anesthetic is administered. Slight reactions require only the head-down position for a few moments. It is probable that the majority of these reactions are due to cerebral anemia and have no relation to the toxicity of novocain. A few inhalations of ether are stimulating in any case and do no harm."

For a detailed description of Lundy's method of producing block anesthesia of the sacral nerves, see that given by Buie.[21] (For detailed instruction for the relief of *intractable pain* with local anesthesia, see the excellent article by Behan.[22] See also the section on Local Anesthesia in the section on Reduction of Fractures.)

[illegible]

[illegible] finger tips, lips and ears may be slightly *cyanotic*; an increased respiratory rate, and nausea and vomiting may be noted. This same [illegible]

[illegible] an intravenous injection has been made, consciousness may be lost, the pupils dilate and *convulsions may begin in a localized fashion* in the face or in an extremity, and later

become generalized. The respirations then become depressed, the blood pressure fall continues, and the pulse may remain slow or become rapid, due to anoxemia.

"The treatment of these complications is comparatively simple and effective, the important initial step being the differentiation of the symptoms with regard to their origin. This is facilitated by keeping an accurate and constant observation of the blood pressure, a detail almost universally neglected with regional anesthesia, save in institutions having a well organized anesthesia department. If it is determined that the reaction is precipitated by epinephrine a few inhalations of oxygen suffice, for its action is evanescent and the condition will speedily wear off. If due to procaine, the patient should receive inhalations of [illegible] distributed over an [illegible] massage, or pos- [illegible] its absorption.

"If the situation is not under control and convulsions intervene, an intravenous barbiturate, such as sodium amytal or pentobarbital sodium, should be given *very slowly* until the convulsions are relieved. If depression is progressive to the extent that the minute volume respirations have fallen to an alarming degree, with a moribund patient, an endotracheal catheter should be inserted, and artificial respiration instituted with oxygen. If respiration suddenly ceases and no anesthetic machine is immediately at hand, mouth to mouth insufflation should immediately be done, until the arrival of the machine to continue artificial respiration. The interval consumed getting the machine after respiration has ceased, may be sufficient to cause death.

"Cardiac depression is encountered rarely with procaine, and only after intravenous injection of large quantities. It has been demonstrated that if the respiratory depression is controlled by an efficient airway and by artificial respiration with carbon dioxide and [illegible] be dis- [illegible] resump- [illegible] correct [illegible] culatory [illegible]

[illegible] could be produced in a limb by the application of a tourniquet and the envelopment with ice of the limb distal to the tourniquet, there has been considerable interest in refrigeration anesthesia. Richards[26] feels that "many of the advocated advantages of refrigeration in infection, shock, traumatic injuries, vascular occlusions and reconstructive extremity surgery seem untenable." He says: "Bacterial growth is retarded by refrigeration but so, also, is the tissue response to inflammation, and on release of the cooling the inflammatory reaction may even be aggravated.

[illegible]

eration anesthesia may be voiced against its use in extensive reconstructive operations on an extremity where a prolonged bloodless and shockless field would be desirable. Similar [illegible] ctive [illegible] it of [illegible] suffi- ciently to prevent recurrent intravascular clotting in the damaged vessel following embolectomy.

[illegible]

permissible, necrosis of the stump is lessened, amputation may be undertaken through a potentially infected field, and subsequent drainage of infection in and healing of the stump controlled by postoperative cooling. The dangers of spreading thrombosis or embolism are obviated. Pneumonia postoperatively must be cautiously avoided."[27]

MINOR SURGICAL PROCEDURES

Spinal puncture is performed for a wide variety of diagnostic and therapeutic purposes.

Verbrugghen[28] says that the indications for spinal puncture fall under two headings:

Diagnostic:

1. To obtain spinal fluid for study.
2. To estimate intracranial pressure.
3. To test for spinal block.
4. To introduce air or lipiodol.

Therapeutic:

1. To introduce sera, penicillin or anesthetic.
2. To remove blood or irritative exudates.
3. To reduce intracranial pressure.
4. To perform spinal drainage.

Spinal puncture consists essentially of introducing a hollow needle into the subdural space of the spinal cord. The position of the patient is of extreme importance for the success of the puncture. That of choice is secured by placing the patient upon his side at the edge of the bed with the spine in hyperflexion. This is obtained by asking the patient to lock his elbows under his knees and tightly draw the knees upward and force the head downward (Fig. 522). Often it will be necessary to have an assistant help maintain this position. Many prefer to have the patient sit upright upon a stool or table and bend far forward with the back in acute flexion (Fig. 523). The purpose of the hyperflexion is to widen the intravertebral spaces and thus to facilitate the introduction of the needle.

Monro[29] says that "lumbar puncture can be done as easily with the patient *lying comfortably* stretched out on his side, as it can with his chin and knees approximated, his discomfort extreme and his apprehension increased on that account. A hasty *glance at any* standard anatomy will satisfy the most skeptical that any significant increase in the separation of the lumbar spinous processes by flexion of the cervical spine and the thighs is an impossibility. The 2 or 3 mm. clearance necessary to introduce a lumbar puncture needle between adjoining bony prominences is available even when *opisthotonos is present*.

"The usual extreme flexion is effective only as a means of restraint in uncooperative or unanesthetized patients and never as a *means of increasing* the ease with which the needle can be inserted. Except in deeply comatose patients the site should be anesthetized adequately with novocaine or the like. To do *this, it is essential* to use first a hypodermic and then a 2 inch small bore needle. [illegible] bony poi[illegible] has the sh[illegible] Only in th[illegible] can the operator and the patient be saved embarrassment and pain, with resulting haste and inefficiency, when, as frequently happens, the needle must be reinserted several times."

The site of the election for a spinal puncture is the aperture between the third and forth lumbar vertebrae. This space is opposite the crest of the ilium. Verbrugghen says: "The ideal place for the lumbar puncture is between the fourth and fifth lumbar vertebrae, which is, as a rule, at the level of a line joining the upper parts of the iliac crests." With the patient in position,

the skin is painted with iodine for an area about a foot square and is draped with sterile towels. The surgeon will scrub his hands, wash them in alcohol and put on rubber gloves. It will be well to make a special mark with iodine to indicate the level of the crest of the ilium as a guide to the site of the punc-

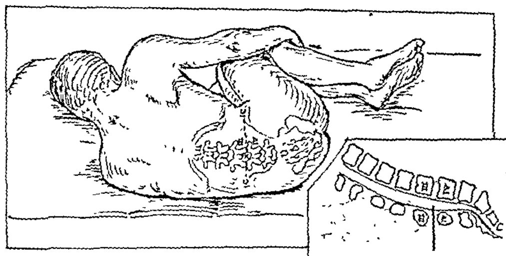


Fig. 522.—Lateral position of the patient for spinal puncture. Site of puncture at *x*.

ture. Careful palpation will demonstrate the depression between the spines of the third and fourth lumbar vertebrae. A wheal in the skin at this point is made by instilling a drop of local anesthetic solution. The needle may be inserted more deeply and a small quantity of the local anesthetic solution

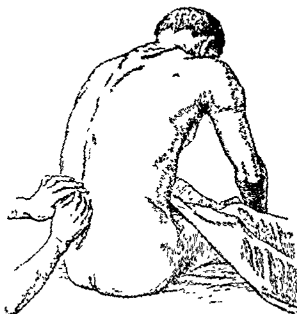


Fig. 523.—Vertical position for spinal puncture. (Maisonnet, J.: Petite chirurgie, Paris, Gaston Doin et Cie, 1928.)

injected below the skin. The point of a lumbar puncture needle is now forced through the skin in exactly the midline between the spines of the third and fourth lumbar vertebrae. One-half inch lateral to the midline is advised by some authorities. After the needle has penetrated the skin it will be well to

check its direction. The spine is viewed from the end to be sure that the needle is directed at right angles to the surface of the back and moreover that it is at right angles to this surface as regards the longitudinal plane. Occasionally it is necessary to point the needle somewhat in an upward direction toward the head. With careful, firm pressure the needle is then forced into the back. It may impinge upon the bony surface of the vertebra, in which case it is slightly withdrawn and the direction modified slightly until it may be felt to pass between the vertebrae to a depth of some 2 inches. When the point of the needle pierces the dura a peculiar sensation of release of resistance will be appreciated. The stylet of the needle is then withdrawn in order that one may ascertain whether the canal actually has been entered. If so, spinal fluid will at once drop out through the end of the needle. If not, the needle should be withdrawn part way and then reintroduced after its direction has been checked. Spinal puncture never should be taken lightly. When the procedure is done for purposes of diagnosis in a case of suspected skull fracture, it is important that only a small quantity of fluid be withdrawn and this slowly. A rapid release of pressure in the spinal canal in cases of increased intracranial pressure has brought about immediately fatal results by the forcing of the brain stem into the foramen magnum. A sterile flamed test tube should be in readiness to catch this fluid. About 3 or 4 cc. should be put in each of three test tubes when a routine examination is desired. In case it is desired to estimate the pressure of the spinal fluid, a manometer is attached immediately upon withdrawal of the stylet. The needle devised by Dr. Harry Jackson is equipped with a two way valve and petcock so that the spinal fluid may be withdrawn and observations of pressure may be made at the same time, thus making it possible to withdraw the amount of fluid desired to reduce the pressure to a certain level. In this connection it will be well to call attention to the presence or absence of a hydrostatic block of the spinal canal above the site of the spinal puncture. Here pressure is made upon the jugular vein on each side (*Queckenstedt test*), with the result that egress of blood from the cranium is barred and the intracranial pressure is increased. This in turn will increase the pressure in the spinal canal, which will be registered by the manometer *unless* a complete block has occurred above the lumbar puncture needle. As a control of this test, in cases in which no increase of pressure is recorded after pressure upon the jugular vein, pressure upon the lower part of the abdomen by increasing the intraperitoneal pressure, and in consequence the communications to the lower part of the spinal cord, should cause an elevation of the pressure registered by the manometer. The patient should rest for from twelve to twenty-four hours in a horizontal position after spinal puncture. In the University of Michigan Department of Syphilology there was but 1 death in connection with 13,000 spinal punctures.

Pearse[30] called attention to the fact that in performing lumbar puncture it is possible, unknowingly, to introduce the needle too far, penetrating the intervertebral disk of the vertebra. The sequel of this may be narrowing of the intervertebral space, which can be demonstrated by [illegible] tions may be set up [illegible] report 5 cases with [illegible] .atment was fixation [illegible] plaster of paris cast. Injury to the intervertebral disk during spinal puncture is also reported by Gellman.[32] In discussing the headache which sometimes follows spinal puncture, Verbrugghen says: "One of the characteristic features of spinal puncture headache is

that the patient has it only when the head is raised and has no headache with the head lowered. This change is practically instantaneous. When the headache occurs the usual procedure is to keep the patient flat for twenty-four hours after the puncture without a pillow; he is allowed to turn from side to side, but he is not allowed to raise the head. The head of the bed is gradually raised over a few hours until the symptom disappears. There is no special treatment employed for persistent spinal puncture headache, except to keep the head lower than the feet and gradually to elevate the head of the bed until the headache is gone. This may take several days. A grain of codeine and 10 grains of aspirin every four hours will relieve the majority of the patients."[28]

Aspiration of the chest is done as either a diagnostic or a therapeutic procedure. (For indications and the amount of fluid to be aspirated, see the section on infections of the pleural cavity and their treatment by aspiration.) *Before the aspiration is done the chest wall is percussed with the patient seated* in the upright position in order to determine the upper limit of the fluid level. Roentgenograms of the chest made with the patient upright or horizontal are very useful. This level may be marked upon the skin with ink or blue pencil as desired. The aspiration is best performed with the patient seated and with the arms well forward. If this is not possible, the aspiration may be done with the patient lying on his side near the edge of the bed. An area about *10 inches square is painted with tincture of iodine and, if possible, draped* with sterile towels. A small wheal is made in the skin with the local anesthetic at the site of the aspiration. The site of election of aspiration is just *posterior to the posterior axillary line between two ribs and a little toward* the superior surface of the lower rib. This latter precaution is taken in order to avoid injuring the intercostal artery and nerve. It is generally wise to infiltrate the subcutaneous tissue beneath the wheal down to the pleura with the local anesthetic. The aspirating needle is firmly grasped and introduced through the skin. When forcing it through the chest wall care must be taken that it does not suddenly plunge into the pleural cavity after the chest wall has been penetrated and thus injure the lung parenchyma. For diagnostic purposes a little syringe will have been first attached to the aspirating needle and the desired amount of the fluid or pus aspirated and placed in a sterile test tube. Care must be taken not to permit the entrance of air through the aspirating needle, because of the possibility of causing collapse of the lung if the needle enters the free pleural cavity. If it is desired to remove a large quantity of fluid, this may be done either by using two alternating Luer syringes which quickly are attached to the aspirating needle so as to minimize the likelihood of entrance of air, or by a negative pressure suction apparatus. After the withdrawal of the aspiration needle it will be wise to seal the wound with a drop of collodion. (*See the important section on treatment of infections of the pleural cavity by aspiration.*)

Paracentesis abdominis, "puncture of the abdominal cavity, may be done for the following purposes. (1) to remove ascitic fluid for palliation; (2) to remove fluid from the peritoneal cavity for gross and microscopic examination as an aid in diagnosis; (3) to produce pneumoperitoneum; (4) to introduce a peritoneoscope for direct visualization of the peritoneal cavity and its contents; and (5) to inject various therapeutic agents into the peritoneal cavity."[33] Ascites is often found in intra-abdominal malignant disease and in cases of cardiorenal decompensation. It may be present in so great an amount that respiration is embarrassed and paracentesis will become imperative. The procedure is without danger except in those conditions, such

as tuberculous peritonitis, in which one might suspect that loops of bowel are adherent to the abdominal wall at the site of the aspiration. The aspiration is generally best performed with the patient seated in a chair and the trocar inserted low down, 2 to 4 inches below the umbilicus, in the midline of the abdominal wall. The bladder should be empty. A greatly distended bladder may be confused with ascites, and this doubt should be ruled out even if catheterization is necessary. It is improper to aspirate an ovarian cyst, and this condition should be ruled out, if possible, in making the diagnosis. The skin is painted with iodine and draped with sterile towels. The skin and underlying tissues are infiltrated at the puncture site with local anesthetic. The trocar being of rather large caliber, it is generally better to make a $\frac{1}{8}$ to $\frac{1}{4}$ inch incision before introducing it. It is important not to insert the trocar through the abdominal wall any more than is necessary to penetrate the peritoneum. If the intestine or omentum is swept up against the inside open end of the cannula, the flow of fluid will stop even if a large quantity of fluid is still present in the abdomen. Change of position or tem

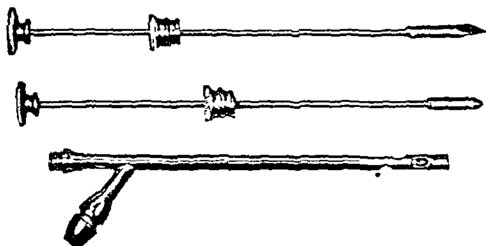


Fig. 524.—Improved cannula and trocar for use in paracentesis abdominis. (Fontaine, B. W.: J. A. M. A. 84: 1179, 1925.)

porary insertion of the mandarin will generally remedy this difficulty. It is advisable not to withdraw the fluid too rapidly because of the likelihood of syncope. The patient's pulse should be watched carefully throughout the procedure as it may be impossible to withdraw the entire amount of fluid. Fontaine[34] has devised an improved cannula and trocar for use in paracentesis abdominis. This writer has used an Ochsner gallbladder cannula with two trocars, one sharp pointed and the other blunt pointed. The cannula with the sharp-pointed trocar is introduced into the abdominal cavity. As soon as the fluid appears in the cannula, the sharp-pointed trocar is withdrawn, and the blunt-pointed trocar is placed in the cannula, screwed in place and drawn out far enough to permit free drainage. In addition to the opening at the end of the cannula, Fontaine has added four lateral openings at intervals at the lower end (Fig. 524). The author has secured a more prolonged drainage by opening the abdomen in the midline under local anesthesia and suturing to the wound three soft rubber (Penrose) tubes which extend about 2 inches into the peritoneal cavity.

Neuhof and Cohen[35] recommend *abdominal puncture for the diagnosis of acute intraperitoneal disease* by means of a spinal puncture needle and a 20 cc. syringe. Only a few drops of fluid may be obtained, but this may be sufficient for a diagnosis. "The theoretical danger of penetrating a loop should not

obtained by diagnostic paracentesis.

In a group of patients who had been injured, the presence of blood or fluid as indicated by puncture was proved by subsequent laparotomy. In a group of patients with pneumococcic and streptococcic peritonitis, the discovery of the organism on abdominal puncture

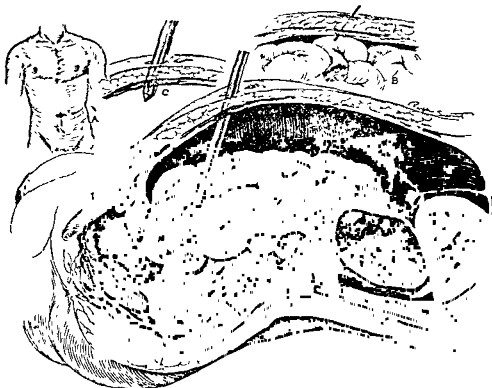


Fig 525 —Technic of peritoneoscopy. *A*, Usual site of puncture, *B*, insertion of pneumoperitoneum needle; *C*, insertion of trocar; *D*, visualization of peritoneal contents with peritoneoscope (Ruddock, J. C . Surg , Gynec. & Obst. 65: 623, 1937.)

prevented an unnecessary operation. The finding of fluid the color of beef juice and containing polynuclear leukocytes but no bacteria has decided the diagnosis of acute pancreatitis and the withholding of operation Fatal hemorrhage has followed abdominal paracentesis.[37]

Peritoneoscopy.—Peritoneoscopy is the visualization of the interior of the peritoneal cavity by means of an optical instrument. It is only suitable for chronic cases. Ruddock[38] says that "peritoneoscopic accuracy, as noted in a statistical study of 409 cases studied, is 91.7 per cent as compared to the clinical accuracy of 63 9 per cent." The technic of Ruddock (Fig. 525) is as follows:

"No preparation is necessary before the examination other than ¼ grain of morphine about 20 minutes before the puncture is to be made. The site of puncture is selected and

A small stab incision is made just large enough to admit the sheath of the instrument snugly, and the point of the knife is carried down until the fascial layers are nicked. The pneumoperitoneum needle is inserted into the abdominal cavity gently and moved around in a circle to determine the presence of adhesions or fixed bowel at the point of entry. The abdomen is then distended with air and the pneumoperitoneum needle is removed. The sheath with the bistoury tipped obturator, which acts as a trocar, is now inserted into the abdominal cavity. When ascitic fluid is present, the insertion is exactly the same as the insertion of a trocar preparatory to an abdominal paracentesis. It is necessary in all cases that the abdominal wall be tense and fixed, either by distention of abdominal cavity with fluid or air or both. The puncture must be carried out steadily and cautiously with the instrument pointing to either side of the spinal column, so that if the entrance into the cavity is made suddenly the gut will not be injured against the bony column.

"As soon as the entrance has been accomplished the obturator is removed and the telescope is inserted. If fluid is present suction is applied with special evacuator inserted in the sheath and the abdomen emptied. This is done entirely with closed drainage. After evacuation of the cavity the air bulb is connected and the abdomen is distended with air. Ordinary atmospheric air is used. It is not necessary to measure the quantity of air used, as the abdominal cavity is not sensitive to inflation, and the patients do not complain of any other sensation except one of fulness.

"As soon as the abdomen is distended, the peritoneal cavity and its contents become visible, and the examination may proceed. Upon completion of the examination the air is allowed to escape. One may assist the evacuation of air by pressure with the hand flat on the belly. Having evacuated the air, the instrument is removed. In cases of ascites the ascitic fluid may drain for a day or two. In cases without ascitic fluid one skin stitch or skin clamp is used and a simple dressing is applied. No disability follows, and the patient is allowed to eat his meals without interruption." (See Ruddock's article for further details.)

Benedict[39] has made 48 peritoneoscopic examinations. In one case pneumoperitoneum may have been a contributory cause of death. ... stances by Garr... toneoscopic exam... are: cirrhosis, malignancy of the liver, tuberculous peritonitis, peritoneal malignancy, ectopic pregnancy, intraperitoneal hemorrhage, pelvic pathology and the determination of operability in malignancy of the stomach. In 44 cases the diagnosis was proved by either operation, biopsy or autopsy. In this group the clinical diagnosis was accurate in 54.5 per cent of the cases, while a 90.9 per cent accuracy was obtained with the peritoneoscope.

Narancio and his associates[42] have found peritoneoscopy to be of great value in the differential diagnosis between cirrhosis and malignant tumors involving the liver. They add that the resectability of cancer of the stomach cannot be forecast on peritoneoscopic inspection of the liver, peritoneum or abdominal viscera alone. Boehme[43] and others call attention to the need of regulation of the prothrombin time with vitamin K before peritoneoscopy is carried out in jaundiced patients.

Olim says that an attempt should be made to evacuate air after the examination. Shackelford[44] reports a series in which he believes 27 useless laparotomies were prevented by peritoneoscopic examination. Hamilton[45] uses a supplementary rod through a separate paracentesis opening to push aside obstructions to peritoneoscopic vision. Chaffee[46] emphasizes the value of postmortem peritoneoscopy in learning the use of the peritoneoscope.

Incision of the Tympanic Membrane (Paracentesis). (See the section on *Otitis Media.*) This procedure is performed both as a *curative* and as a diagnostic ... *matory aural infections* The pa... meatus by irrigating it with wa... *tions of the external meatus and ear may be cleansed with alcohol. In certain cases anesthesia may be omitted, but because this operation is extremely painful some type of anesthesia is generally necessary.* Gray[47] fills the canal with a warm aniline cocaine solution of the following formula:

Cocaine cryst.	gr. xij-xxiv
Aniline oil	drachm j
Absolute alcohol	drachm j

A 5 to 10 per cent solution of phenol in glycerin is useful but requires a longer time to bring about anesthesia. Nitrous oxide or ethylene to bring about general anesthesia is preferred. It is desirable, if possible, to have the patient seated upright during the administration of such an anesthetic so as to present as normal relationships of the quadrants of the membrana tympani as are usually seen.

Through the largest speculum that the external auditory meatus will accommodate a thin paracentesis knife is introduced. The most important point in the choice of an incision is the avoidance of the attachment of the auditory ossicle. The incision is generally made in one of the lower quadrants of the membrane, but in certain cases a superior quadrant will have to be incised. (See Fig. 130.) After the paracentesis has been performed the external auditory meatus should be loosely packed with sterile cotton to absorb the discharge.

Venipuncture; Phlebotomy.—Phlebotomy is the opening of a vein for the purpose of bleeding the patient or of withdrawing blood for examination. It is done either by placing a needle in the vein itself or by cutting the vein. Venipuncture is the introduction of a hollow needle into a vein for the purpose of withdrawing blood or introducing fluids. It is usually carried out with a blood pressure apparatus or tourniquet proximal to the site of puncture so that the vein is distended. (See Blood Transfusion.) Lundy[48] says

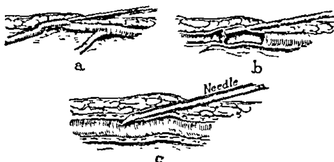


Fig. 526.—*a*, Ball valvelike action of vein wall against opening of needle; *b*, flapping of vein valves against opening of needle; *c*, dissection of vein wall causing partial obstruction at opening of needle. (deBakey, M. E.: Am. J. Surg. 27: 85, 1935.)

that the application of moist heat to an extremity is a valuable aid, but it is not effective unless, when a vein in the upper extremity is to be punctured, the hand, wrist, forearm and arm to a point above the elbow are enveloped in a warm, moist Turkish towel with an outer wrapping of oiled skin or rubber and unless hot water bottles are laid against the rubber covering. When a vein in the ankle is to be used, the entire foot, ankle and leg to the knee should be covered by the towel and exposed to heat. With the extremity in the dependent position and after about twenty to thirty minutes' application of heat in this manner, the hand, wrist, forearm and arm become congested with blood so that when the tourniquet is applied the veins stand out prominently. The common failure of this measure is attributable to the fact that usually the moist heat had been applied to the elbow but not to the hand, wrist and forearm and so fails to accomplish its purpose. The vein itself is put under some tension so as to steady it and the needle is carefully passed through the skin and then guided by the sense of touch into the lumen of the vein itself. Most physicians, but not all, find it more convenient to have the bevel of the needle pointing upward. DeBakey[49] has illustrated the difficulties which may be encountered when introducing a needle into a vein (Fig. 526). See figure 547 for a diagram of the superficial veins used in giv-

ing a blood transfusion. For the technic of phlebotomy of the internal jugular vein, see the original article by Hoover and Lundy.[50] If venipuncture must be repeated to obtain blood specimens over a period of several hours, Rhode[51] uses a spinal puncture needle with stylet. The needle is taped to the arm and the stylet withdrawn when blood specimens are needed and then replaced.[52]

Intravenous Infusion (Venoclysis; Intravenous Drip).—Intravenous infusion is the term applied to the introduction of various fluids into a vein. The introduction of *intravenous medication* is, in reality, a small infusion, and the same technic should be observed. It is used under a wide variety of conditions but particularly in shock when normal saline, Ringer's solution, dextrose-Ringer's solution, or various other solutions will be employed. The usual method is to place the patient's arm out to the side on an arm-board



Fig. 527.—Introduction of needle into a vein on the dorsum of the hand for intravenous administration of solution.

and to apply a tourniquet 3 or 4 inches above the elbow, just tight enough to obstruct the venous circulation. The blood pressure apparatus is preferable as a tourniquet. The skin of the anterior surface of the elbow is painted with iodine and washed off with alcohol. The patient is instructed to open and close his hand several times so as to distend with blood, as much as possible, the veins of the arm. The needle which is connected by rubber tubing to the flask containing the desired solution at body temperature is now inserted into the vein, pains first being taken to allow a little of the fluid to run out of the needle to insure the absence of air. It is much more convenient and comfortable for the patient if a vein on the dorsum of the hand or at the ankle is used (Figs. 527, 528). The splint for intravenous infusion described by Zeigerman[53] is useful. For the technic of venipuncture of the external jugular and internal jugular veins, see the article by Lundy and his associates.[54] Lundy[55] has devised an improved ring pinch clamp

for use in intravenous therapy. Titus[56] has described a most convenient combined needle adapter and thermometer for intravenous infusions.* The technic of placing the needle in the vein (*venipuncture*) is well describèd by Tuohy and Lundy[57] (Fig. 529). To facilitate the introduction of the needle in the vein a 2 cc. Luer syringe with a side connection is extremely valuable. By withdrawing the piston of this syringe one may definitely ascertain whether or not the vein has been entered, as the blood will then flow back into the syringe. As the piston is further withdrawn, communication will be established between the vein and the side connection, and the infusion fluid which is under pressure will begin to flow into the vein (Fig. 531). At this point, of course, the tourniquet will be removed. The solution must not be allowed to flow in too rapidly, for fear of increased pressure in the right side of the

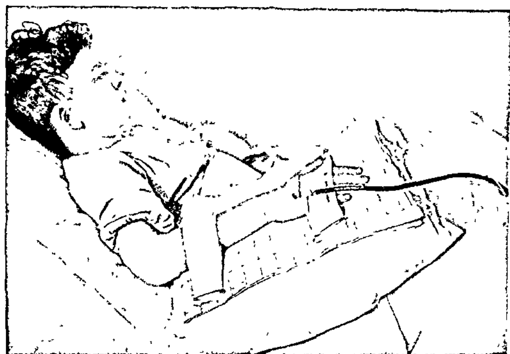


Fig. 528.—Venoclysis. (Gallie, W. E., and Harris, R. I.: Ann. Surg. 91: 422, 1930.)

heart. Occasionally it will be necessary to infiltrate the skin with a local anesthetic and to cut down upon the vein and insert into it and tie in place a small cannula. (See the method employed in blood transfusions.) Schwentker[58] has evolved a special technic for intravenous therapy for children. He employs a three way stopcock connected to the flask, the needle and a 20 cc. syringe. He believes the most suitable veins in infants are the superficial temporal veins of the scalp or the external jugular veins. The superior longitudinal sinus is used only when all other methods fail. Figure 530 shows the most accessible veins in the child. For an infant, Spivek[59] generally uses the scalp veins in the temporoparietal region when attempting to penetrate the vein through the skin with a needle. He considers direct exposure of the vein to be more reliable. His technic is as follows:

* Titus says: "These infusion thermometers are relatively inexpensive and are made by Becton, Dickinson & Co., Rutherford, N. J."

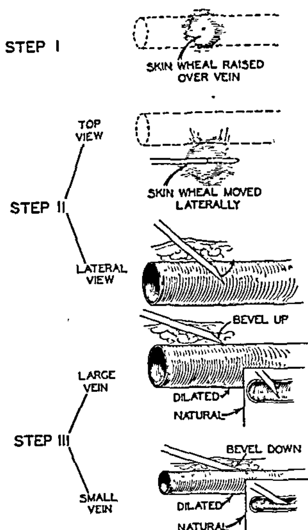


Fig. 529.—Venipuncture, step 1: in very sensitive individuals a wheal is raised with a solution of 1 per cent procaine hydrochloride in the skin overlying the vein. For the majority of adult persons this step is unnecessary. Step 2: the needle is thrust through the skin, not attempting to enter the vein with the one motion, but rather to move the skin which overlies the vein laterally; then the skin should be moved back so that the needle lies against the side of the vein. Step 3: the skin should be moved into position so that the needle overlies the vein. With the constrictor in place, the vein is dilated. If the vein is large, the point of the needle will lie entirely within the lumen, even when the vein is not dilated. On the other hand, when the vein is very small, the point of the needle will not lie free in t[illegible]
is held as [illegible]
the point c[illegible]
the vein with the hand that does not hold the syringe. The syringe is held by the right hand by a right-handed person and the needle is inserted through the skin. The right fingers grasp the plunger and the tip of the right thumb is placed against the edge of the barrel in order to produce the negative pressure. The fingers of the left hand are pressed against the skin overlying the vein at a point far enough from the point at which the needle enters the skin so that the left hand in no way interferes with bringing the needle and syringe flush with the patient's skin. Unless this counterpull with the left hand is exerted, venipuncture may become very difficult, especially in the veins around the wrist and in the hand, because they are movable and must be fixed if they are to be entered easily by the needle. This counterpull must be exactly opposite to the direction of the insertion of the needle. The tourniquet should be placed fairly close to the site of venipuncture and should anchor the vein from above. (Tuohy, E. B., and Lundy, J. S.: S. Clin. North America 20: 1093, 1940.)

"The technic is quite simple but does require strict adherence to detail. The vein most commonly used is the small saphenous found just anterior to the internal malleolus. This vein cannot always be seen; but if it is present it can always be felt by drawing the thumb

plied to the underside of the splint at the heel side. It passes up and over the heel over the medial aspect of the foot and toes and down and around the underside of the splint around once more to the heel side over the instep and down and around to be secured on the underside of the splint. If this has been correctly done, the foot is firmly bound to the splint. The assistant seated alongside of the baby holds the splint down on the table. This method of holding immobilizes the splint and so the foot.

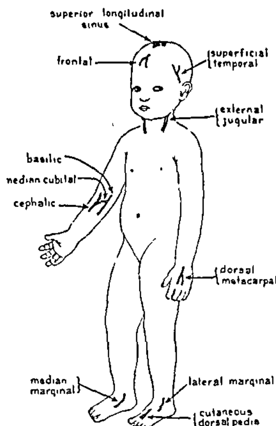


Fig. 530.—Veins accessible for intravenous therapy in infants. (Schwentker, F. F.: Internat. S. Digest 11: 3, 1931.)

"The site of operation is prepared with iodine and alcohol. The adhesive tape immediately adjacent is also liberally sponged with the solution since it sometimes projects into the field. With the vein's position definitely known, a local anesthetic is injected directly over the center of the vein. The wheal raised obliterates the vein, but the needle mark

It is made across the course of the vein and directly thru the needle mark so that one-half of the incision lies on either side of it. The vein then lies directly under the

center of the incision. The wound is spread with a forceps and the vein is scooped up with an iris forceps. If successfully done, it lies like a shiny pearl ribbon across the forceps. A piece of catgut is passed under the vein by catching it in the free end of the forceps. This [illegible] vein wall [illegible] from it. [illegible] To secure [illegible] hed tip is [illegible]

"With the needle securely in place, the operator may use any method or apparatus to complete the transfusion. At its completion, the vein is not tied off and no sutures are used to close the incision. A tight pressure bandage controls bleeding and allows the skin edges to closely approximate, giving eventually a small scar.

"If continuous intravenous fluids are to be given, the needle is tied into place with a dermal ligature and the needle and canula are taped securely to the skin of the ankle."

When attempts to enter the vein with a needle are unsuccessful, it is necessary to cut down on the vein and place a cannula in it (*vein cannulation*).

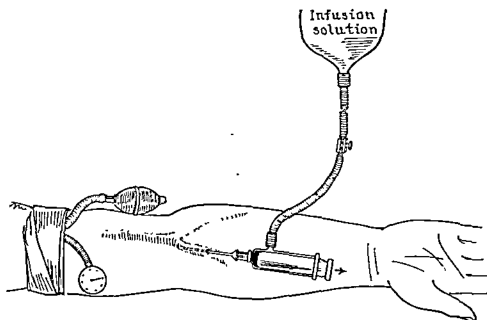


Fig. 531.—Side connection syringe for use in giving an infusion. As the piston of the syringe is withdrawn, blood from the vein enters until the piston is drawn past the side connection, when the infusion solution starts to flow into the vein.

The technic of this procedure is described by Keeley[60] as follows: "Local anesthesia is entirely satisfactory, the infiltration of the skin and the subcutaneous and paravenous tissues being somewhat more extensive than that described for simple venipuncture. A transverse incision ½ to 2 cm. long, depending on the amount of subcutaneous tissue present, is made directly over the vein. The subcutaneous tissue is separated from the vein by blunt dissection parallel to the vessel, using a small curved hemostat. The entire circumference of the vein must be freed for a distance of about 1 cm. before it is encircled by two ligatures of fine silk or catgut. The distal ligature is tied. Traction on the proximal ligature or the use of a small bull dog blood vessel clamp will prevent loss of blood when the vein is opened. By upward traction on both ligatures the vein is immobilized. A fine pointed bistoury is passed transversely through the wall of the vein at two opposite points and is then drawn distally and upward to make a flap in the vein

wall. An alternate method with fine scissors may be employed. By grasping the tip of the flap and the ends of the incision in the vein with fine mosquito forceps, a suitable cannula may be introduced and tied in place, using a bow knot. The necessary skin sutures are put in place while the local anesthetic is still effective. When the infusion is completed the bow knot is untied, the cannula is removed and the ligature is tied permanently. The skin edges are approximated by the stitches which are already in place." If it is extremely difficult to enter a vein, Phelps[61] suggests injection of blood or citrated plasma into the corpus cavernosum of the penis. The femoral vein may be used and the needle left in for several days. This was done in cases of bad burns at Iwo Jima and Okinawa.[62] The use of the saphenous vein is described by Vallone.[63] The dorsum of the hand and the forearm are very convenient sites for intravenous infusims.

Reactions not infrequently follow intravenous infusions. Nelson[64] says that they "are the result of bacterial contamination of the distilled water used in the preparation of the solutions. I have found that the use of the commercially prepared intravenous solutions has practically eliminated reactions."[65] Hassin[66] reports 6 cases of injuries to the large nerve trunks of the upper extremities caused by the intravenous injection of dextrose and says that "it is a wonder that accidents to the large nerves are not more frequent."

Venoclysis.—Venoclysis is the term applied by Hendon[67] to the procedure of continous administration of fluid into a vein originated by Matas. (See section on Postoperative Care.)

Hendon says that the continous administration may be kept up as long as twenty-one days but that five days is about the average time that one vessel will remain sufficiently patent to convey the fluid. Horsley and Horsley[68] have used venoclysis in 750 cases and say that in shock and hemorrhage the rate of flow of the solution "should be rapid enough to secure almost a normal blood pressure within a short time." "For conditions other than shock or hemorrhage, the solution should be given at a rate of from 75 to 200 cc. per hour." The rate of flow according to Gallie and Harris,[69] may be "as low as 500 cc per day without clotting."

Tomarkin and Strauss[70] review 3 clearcut cases from the German literature of embolic deaths which were directly traceable to emboli arising in thrombophlebitis of the arm vein used in venoclysis. They add, "As soon as the solution begins to back up in the tubing, it is a sign that the lumen of the vein is becoming compressed by edema of the wall. If the

[illegible]

as dire result as in the case cited above." Bohn[71] reports a case of nearly fatal air embolism with misuse of a positive pressure apparatus for intravenous fluid administration. The patient recovered after aspiration of about 50 cc. of blood-stained froth from the left external jugular vein

Hyman and Touroff[72] indorse the intravenous drip method enthusiastically in the following words:

"The intravenous drip has won a permanent place in therapy in our institution The

[illegible]

and but 1,539 subcutaneous sets. To date in 1934, 1,949 intravenous sets have been used, and only 322 clysis outfits. In comparison with hypodermoclysis, the intravenous drip has the advantage of more certain absorption, greater adaptability, less discomfort to the patient, and the possibility of adding drugs and whole blood directly into the circulation. At the seemingly slow rate of 2 or 3 cc. per minute, the drip will introduce daily between

2,500 and 4,000 cc. of fluid and may be continued for several days or even weeks, as in patient 18, who received a drip for twenty-four days.

"*Once the drip* is in operation, it is impressive to observe the ease of management of extremely difficult and complicated conditions. By the single technical procedure the problem of nutrition and of the introduction of fluid, salts, drugs, blood and serum becomes automatic."

[illegible] to be more satis- [illegible] 74 believes that [illegible] the elimination [illegible]

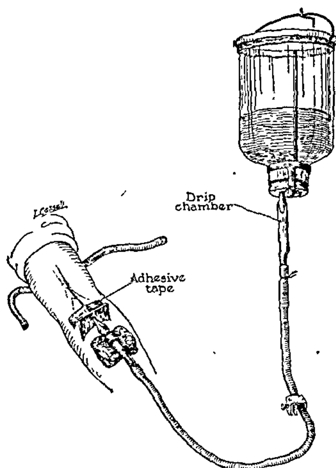


Fig. 532.—Intravenous administration of fluid.

hydroxide for 12 to 24 hours, washing in running water for 2 hours and boiling in distilled water for ½ hour before using Since this was done we have had but 3 reactions from some three thousand liters of solution, 2 of which could be definitely traced to the necessity of cleaning the still, and all of which were mild. Rubber tubing offers another possible difficulty, however, in that it is frequently not sufficiently cleaned before using a second time, and contamination of the tubing occurs. This is especially true if a blood transfusion had been previously given. Scrupulous cleanliness and allowing waste of 100 cubic centimeters of solution through the needle before insertion into the vein are safeguards of this possibility."

Proctoclysis.—Although water is preferably administered by intravenous infusion or hypodermoclysis (see sections on infusion and hypodermoclysis) to the patient who cannot drink, it can also be given by rectum (proctoclysis). By means of a catheter or small rectal tube, tap water is given by

the drop method (Murphy drip) or by means of 4 to 6 ounce retention enemas every four hours. There is dispute as to whether or not dextrose can be absorbed from the rectum.[75]

Sternal Infusions (See Sternal Marrow Aspiration).—When peripheral veins are collapsed and difficult or even impossible to enter, as in cases of severe shock or hemorrhage, sternal infusion can be a life-saving measure. Tocantins and his associates[76] have shown that the bone marrow offers an ideal site for the rapid introduction of fluids into the central circulation until such time as the peripheral circulation is restored and access to the veins is again feasible. Tocantins generally uses the sternum, but in children the tibia or femur may be employed. Any physician who intends to employ interosseous therapy should first read the important article by Tocantins and O'Neill[77] in which the complications and the means of avoiding them are discussed in detail.[78]

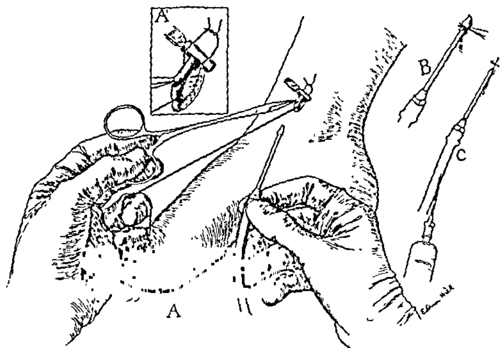


Fig. 533.—Venoclysis. (Warthen, H. J.: Internat. S. Digest 10: 3, 1930.)

Several types of needles may be employed.* Jones describes the technic of sternal infusion with his needle as follows:

"The following technique may be used in administering fluids intrasternally. The plasma, albumin, blood, or other fluids are made ready to be given. The site for administration, usually the manubrium or the body of the sternum opposite the 2d or 3d interspace, is chosen, and the overlying skin is cleaned with iodine and alcohol or an acetone-alcohol-mercurial mixture. The skin and underlying tissues down to the sternum are anesthetized with procaine. The needle is inserted through the skin down to the bone in the midline. Then, with the point toward the head, *and at an angle of about 45 degrees with the sternum,* the needle is forced into the marrow cavity with pressure and a rotary, boring motion.

* The Tocantins and O'Neill needle, supplied by Geo. Pilling Co., Philadelphia; the [illegible] War Med. 2: 277, 1942), [illegible] he simplest needle seems [illegible] & Obst. 76: 587, 1943), which is supplied by V. Mueller & Co., Chicago. (See Fig.535.)

fluids,
is atter

logical saline by syringe to start the flow when the drip method is used. When large quantities of fluid are given over a long period of time, it is well to remember that the velocity of flow sometimes tends to increase with time, and that this increase should be controlled to prevent circulatory embarrassment." Tocantins, O'Neill and Price report the giving ... of 1150 cc. in twenty minutes ... 1675 cc. of fluid was given

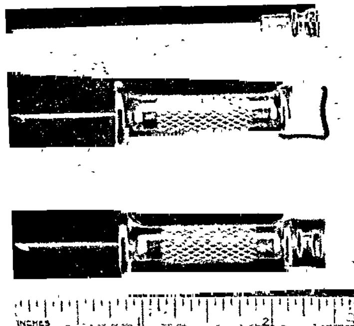


Fig. 534.—The upper figure shows the needle for administering plasma and fluid. The lower figure shows the needle assembled. Note the flange on the hub and the knurling. (Jones, R. M.: Surg., Gynec. & Obst. 76: 587, 1943.)

The Turkel needle (Fig. 535) is admirable. Its use is described by Turkel and Bethell[80] as follows: "The outer needle and stylet are pierced through the skin until the bone is reached; then the stylet is replaced by an inner trephine needle, which drills a hole through the anterior lamella and retains the entire core instead of breaking it up into particles. The outer needle is then pushed a predetermined distance into the prepared hole with little force. The inner needle is removed; and after the presence of the tip of the outer needle in the sternal cavity has been verified by aspiration with a syringe, the instrument is ready for infusion."[81]

Hypodermoclysis is a term applied to the subcutaneous administration of large quantities of fluid. Saline and Ringer's solutions are the fluids generally employed; dextrose-Ringer's solution causes more pain but is indicated when there is definite caloric requirement; 3,000 or 4,000 cc. may be given in twenty-four hours. The best site for the hypodermoclysis is the outer middle surface of the thighs. It is to be remembered that the injection

is into the fatty tissues just beneath the skin. The anterior surface of the thighs, the flanks and the loose tissues at the sides of the chest below the axillas are also suitable. Kolodny[82] has observed that infusion into the cellular tissue under the pectoral muscles leads to a marked increase in the frequency of the respiratory excursions and later to a fast pulse. When there is pain due to wounds of the upper part of the abdomen, expectoration, respiration and ventilation of the lungs are insufficient. The breathing is more thoracic than abdominal, being shallower and more rapid. In these cases hypodermoclysis of the chest wall is a further embarrassment to the chest movements. Kolodny prefers the giving of the hypodermoclysis in the outer aspects of the thighs (Fig. 536). In the urgency of the circumstances under which a hypodermoclysis often is given, attention to the necessity of asepsis is often relaxed. A subsequent abscess at the site of the injection is regrettable and often a serious complication. The skin for an area of 5 inches about the site of injection is carefully painted with iodine. A sterile towel is placed over the upper part of the abdomen. At the point of injection a

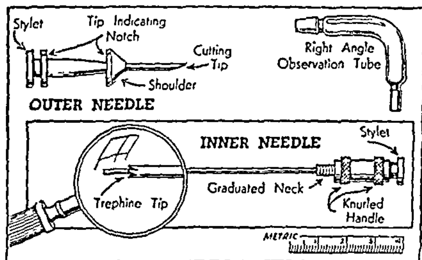


Fig. 535.—Turkel sternal puncture needle.

skin wheal made with a local anesthetic will greatly decrease the patient's discomfort. In children or in restless or delirous patients, it is important that the needles be well guarded so that they will not pull out or be contaminated. The fluid must be observed to be flowing freely through the needles before they are inserted and the apparatus must be free from air. The apparatus is equipped with two needles (Fig. 537), one of which is used for each thigh (four needles are preferable). It will be well to introduce the needles for a distance of about 2 inches and from time to time to vary that position by withdrawing them 1 or 2 inches and reinserting them in a different direction. The space between the subcutaneous fat and the aponeurosis is probably the best for the deposition of the fluid. Too rapid distention of the tissues with solution is extremely painful, and the best procedure generally is to delegate to the nurse or attendant the control of the rate of flow. This is done by setting a screw pinch-cock on the rubber tubing at such a degree of tension as will be most comfortable to the patient. From time to time it is desirable to shut off the flow altogether and to wait until

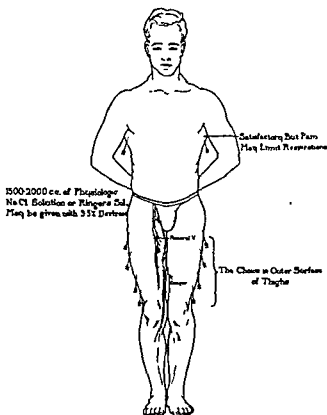


Fig. 536.—Sketch showing suitable locations for hypodermoclysis needles. (Courtesy of Dr. Thomas G. Orr.)

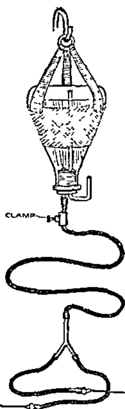


Fig 537.—Apparatus for hypodermoclysis. (Kanavel, A. B., and Koch, S. L.: Bull. Am. Coll. Surgeons 1: 3, 1928.) A commercial flask is equally useful.

some of the fluid has been absorbed before proceeding. Over a period of one to two hours 1,500 to 3,000 cc. of solution may readily be introduced subcutaneously. Gentle massage, by the nurse, of the distended tissues will facilitate absorption and will give comfort.

Parenteral Fluid Administration Beneath the Fascia Lata.—Finley and his associates[83] give the technic of this method as follows: "After the skin on the lateral aspect of the thigh is prepared with a good skin antiseptic, the standard eighteen gauge hypodermoclysis needle is inserted at about a forty-five degree angle to the skin. The point of preference is at the junction of the lower and middle third, lateral surface, and equidistant between the anterior and posterior aspects of the thigh. The needle is inserted to the fascia lata, where a sensation of 'give' is felt as the point passes through the fascia. The point is allowed to remain at this depth although it may have to be altered slightly until the best rate of flow of the solution is obtained. The solution is suspended approximately three feet above the legs and allowed to run as rapidly as possible. Only rarely is it necessary to check the rate of flow. The needles are not taped to the skin, since they are held in place quite firmly by the fascia. There is no danger of breakage of the needle, if it is not taped, since the fascia acts as the only fixed point and the needle is permitted to swing slightly if necessary. A pillow beneath the knees relaxes the fascia and facilitates insertion of the needles. In unconscious patients, the knees are lightly tied together." The authors say: "In 261 consecutive subfascial infusions of 1,000 cc. of saline or 5 per cent dextrose by this method, the average time for delivery of the solution was fifty-six minutes. In thirty-three patients the average time for absorption of the same amount of fluid by hypodermoclysis was 167 minutes. The solution appears to be absorbed rapidly, as shown by excretion of phenolsulfonphthalein dye in the urine. This absorption probably takes place in the extensive loose areolar space and capillary and lymphatic bed just beneath the fascia lata. There is more rapid absorption in elderly patients, probably because of more lax structures. The rate of absorption is not greatly influenced by the state of dehydration.

"There is minimal swelling and pain in subfascia lata infusion. Because of the decreased discomfort, increased rate of absorption, and unquestionable safety of the method, fluid and electrolyte needs can be replenished several times daily in this way and intravenous solutions restricted, for the most part, to transfusions and hypertonic fluids. The sick surgical patient may be moved in bed frequently, without long periods of immobilization. Finally, the technic of insertion on the lateral thigh is simple and because of the rapidity of absorption, the entire procedure can be left safely in the hands of the nursing staff with elimination of a large amount of nursing time and care."

Vaccination.—In vaccination for smallpox the site of the vaccination is carefully scrubbed with soap and water. It is then washed with alcohol and allowed to dry thoroughly. The glass virus tube is then broken under sterile precautions, and a few drops of the virus are [illegible] the small rubber bulb which is provided. A sterile [illegible]

touched. If the vaccination "takes," a tender indurated ulcer will develop in a few days. There may be considerable discharge. The wound should be kept scrupulously clean and protected by sterile dressing or by vaccination shields. Occasionally severe cellulitis will develop which will require hot boric acid fomentations and other appropriate treatment. Kaiser[84] is impressed with the intracutaneous method of vaccination against smallpox. Apparently the danger of severe pyogenic infection is less, and the protection lasts a year or longer.

Arterial Puncture.—Arterial puncture has been recommended by Glasser et al.[85] for the injection of penicillin for infections of the extremities. Their technic is as follows:

"We mention precautionary measures to be observed before outlining our technic of intra-arterial injection. We are in agreement with Wilmoth in cautioning against transfixion of the artery with the needle. This may be avoided by entering the artery obliquely. It is not essential that the needle be placed in the direction of the blood stream, as mentioned by many writers Rhythmic jets of blood into the syringe must be observed before injecting. Our technic of intra-arterial injection is as follows:

"We employ a 20 cc. syringe to which a gage 20 needle 2½ inches long is attached. In the lower extremity the injection is made into the femoral artery, piercing the skin in the crease of the groin. The left hand palpates the femoral artery, which is best felt above the inguinal crease, especially in obese persons. The artery is fixed between the index and third fingers of the left hand, and the needle is directed from below upward. Close proximity to the artery is noted when an arterial impulse is transmitted from the point of the needle to the syringe. A bright or light colored pulsating stream of blood appearing in the syringe, which contains 50,000 units of penicillin (10 cc.), indicates that the needle is within the lumen of the artery. In the upper extremity, depending on the location of the infection, the brachial artery is punctured at the elbow or more proximally. The blood pressure cuff, which has been applied proximal to the infected area at the beginning of this procedure, is inflated rapidly immediately following completion of the injection, which has been given at the rate of 1 cc. per second. The pressure in the cuff should be 280 to 300 mm. of mercury and is maintained for ten minutes. In order to avoid the possibility of hematoma formation, digital pressure over the puncture site is applied immediately on withdrawal of the needle."

Tracheotomy is the operation of making an opening into the trachea to insure respiration in cases in which the trachea and larynx have been blocked above. A tracheotomy tube is generally introduced into the opening. The operation is indicated in diphtheria, croup and edema of the glottis and in cases in which a foreign body has lodged in the upper portion of the trachea. Certain traumas of the base of the tongue as well as laryngeal fractures may demand it. It is also indicated when intubation fails. Cases are on record in which urgent tracheotomy has been done with a penknife and hairpin retractors. When urgent dyspnea or asphyxiation is threatening, it is better to proceed without proper instruments than to delay indefinitely until they have been obtained. An urgent tracheotomy may be performed as follows: The patient is placed upon the table, one end of which is elevated so that the head is well below the body. The purpose of this is to prevent blood from running down into the trachea. In the case of a child the hands are wrapped to the side in a sheet, with the head in full extension. The cricord cartilage is drawn downward (away from the sternum), and an incision is made about 1 to 1½ inches below the cricoid cartilage. Two or three tracheal rings are incised. There is a marked tendency oftentimes for the tracheal rings to collapse because of the suction exerted by the inspiratory efforts. A useful rough method of maintaining the tracheal opening is the introduction of two bent hairpin retractors on each side of the incision.

When the operation may be done more deliberately, a general anesthetic may be used. Cawthorne[86] says that "local infiltration renders the operation painless and reduces bleeding." The skin is carefully prepared with iodine and alcohol and properly draped. The position of the patient is the same as that described above. A good light is essential. A tracheotomy set of various-sized tubes should be at hand. The best type of tube is the curved one with an inner removable second tube. The operation may be performed at different levels. If above the level of the middle of the thyroid isthmus it is *termed a high tracheotomy. A low tracheotomy is below the midlevel of the* thyroid isthmus. High tracheotomy is more easily performed, but low tracheotomy occasionally is necessary in certain cases of foreign bodies. Cawthorne[86] says: "The trachea must never be incised above the second ring, but preferably through the third and fourth. This will avoid the possibility of subsequent laryngeal stenosis, a permanent tube, and loss of voice for life." The skin is opened in the midline by an incision from the level of the cricoid to 1 or 1½ inches below. Hemorrhage is controlled by clamp and ligature. By blunt dissection the trachea is exposed, care being taken to retract to each side the overlying muscles. The deep cervical fascia is cut through and the thyroid isthmus retracted downward (in the case of high *tracheotomy). A tenaculum hook is fastened into the cricoid cartilage and* held so as to steady the trachea. Two or three rings of the trachea are then cut through by a downward thrust. If a membrane is present in the trachea it also must be incised. The blood and mucus will then be coughed out and wiped out, while the edges of the wound in the trachea are held open. The trachea is swabbed out, and a tracheotomy tube is inserted. The tube is held in place by tapes which are passed around the neck and attached to the tube flanges. It may be necessary to ligate the isthmus. After tracheotomy the patient must be kept in a room in which the air is well moistened. The inner cannula must be cleansed with alkaline solution as often as is necessary to insure its patency.

Skin grafting is indicated, under various conditions, for the covering of large raw surfaces, for the shortening of the time of morbidity and the minimizing of deep scar formation. Beekman and O'Connell[87] say that "skin grafting should be done early in the course of healing, while there is but little granulation *tissue present." McCorkle and Silvani*[88] *say: "A period some-*where between the second and third weeks after an extensive deep thermal burn, is likely to prove the optimum time for excision of nonviable burned [illegible] immediate application of skin grafts of intermediate thickness. [illegible] recovery apparently is earlier." Pritchard[89] has used biopsies as a guide to the best time for skin grafting. Several types of grafts are employed: the Thiersch graft or the thin graft, the small full thickness graft, the thick split graft, Reverdin graft, the free full thickness graft, the pedicle graft and the tubular graft. The thickness of various skin grafts is well shown in the diagram published by Converse and Robb-Smith.[90] (Fig. 538.) The more complicated pedicle and some of the tubular grafts are major problems of plastic surgery.

Of first importance in skin grafting is the proper preparation of the soil for the graft. The presence of any degree of infection is a certain invitation

to failure, except in the case of small Reverdin ("pinch") grafts. A purulent discharge from the wound surface or the presence of little furuncles in the skin in the neighborhood of the wound is a contraindication to skin grafting. According to Blair and Brown,[91] a pimple, even on a remote part of the body, means lowered resistance of the host. All infections should be cleared up by the use of Carrel-Dakin treatment or by hot boric acid fomentations before skin grafting is attempted. Brown[92] prefers saline dressings but will use Dakin's solution if they are not effective. Dressings must be firmly applied and must not be allowed to dry in place.[91]

Brown says: "A firm pressure dressing that is kept moist by irrigation, combined with elevation, may be of great advantage for lesions of the extremities; marked improvement may be noted within forty-eight hours.

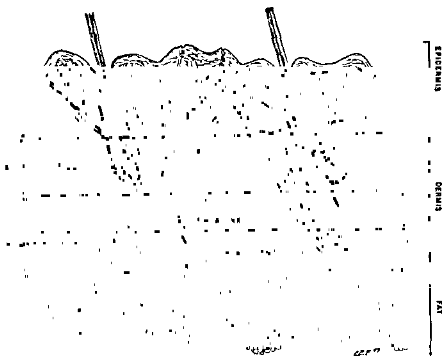


Fig [illegible] afts are removed. *AB*, level of a [illegible] *EF*, level of a thick graft; *GH*, [illegible] nd Robb-Smith, A. H. T.: Ann. Surg. 120: 873, 1944.)

"Pain should be kept down to a minimum when the dressings are removed. They may be soaked off gradually in a bath. It is important that some protector is used next to the wound to prevent the granulations from growing up through the meshes. For this, old linen, perforated cellophane-like material, or very fine mesh gauze is usually satisfactory so that dressings can be removed even from children with a minimum of discomfort. When cellulitis is controlled, grease dressings (xeroform 4 per cent) on fine gauze or linen can be used; these allow the patient greater freedom, but they are not to be used for several days immediately preceding operation. Gentle mechanical cleansing of wounds daily with soap and water is important, but care should be taken not to disturb epithelization."

Penicillin seems to have become a valuable adjunct to skin grafting. According to Hirshfeld and his associates[93] penicillin "appears to prevent the loss of skin from infection that ordinarily occurs in about one third of the cases in which split thickness grafts are placed on contaminated recipient sites." Levenson and Lund[94] found "no demonstrable changes in the cul-

tures of the granulating areas under penicillin treatment, but the takes of grafts were consistently good and in marked contrast to previous experience." Nomland and Wallace[95] say that they "recommend the routine use of penicillin intramuscularly before and after skin grafting in cases of ulcer of the leg that are treated by pinch grafts in which the surface infection is caused by the beta hemolytic streptococcus and hemolytic Staphylococcus aureus, and it could probably be used with benefit for all ulcers, irrespective of the nature of the surface infection."[96]

Gatch and Trusler[97] give the following suggestions for the preparation of the granulating surface:

"If the patient is anemic or debilitated, blood transfusion may be necessary to raise his general resistance. For an infected or sloughing wound, we first employ intermittent soaking in normal or hypertonic salt solution with continuous wet dressings of ½ per cent chlorazene solution. The dressings are changed daily. If during the sta e of sloughing, the granulations become edematous and indolent, they may be scraped away and given a fresh start. Often, however, we have found that such granulations may be rendered firm and vascular by means of a pressure dressing of dry gauze compressed against the wound with elastic bandage or adhesive tape.

"When the wound is of too long standing, with a resulting thick fibrous base, it is necessary to excise this tissue completely and allow a thin layer of granulations to develop on healthy tissue. The same procedures are essential in the correction of extensive scar contractures where wide excisions are necessary to relieve deformity.

"When in any case these measures have insured an adequate blood supply to the granulations, the problem of infection is still to be dealt with. In the presence of purulent exudates, the grafts are floated loose and destroyed by proteolytic ferments. Even with lesser [illegible] cum of co- [illegible]" [illegible] ion tissue. They use a very thick Thiersch graft.

Webster[98] has used refrigerated Padgett dermatome grafts up to three weeks after removal. Strumia and Hodge[99] used grafts successfully which had been preserved in the frozen state for as long as sixty-one days.

There has been considerable interest in various methods of fixation of skin grafts. In the Sano[100] method, pressure dressings and sutures are not employed to fix the grafts. In 100 square inches of skin grafted by the Sano method, only 1 square inch was lost. The method is as follows:

"Into a 10 cubic centimeter syringe containing 1 milligram of heparin dissolved in 1.0 cubic centimeter of Tyrode's solution (a buffered salt solution), 5 cubic centimeters of the patient's blood are drawn. The blood is centrifuged and the plasma transferred to a small 5 cubic centimeter test tube, all procedures being done under sterile conditions. One and a half cubic centimeters of Tyrode's solution are added to the remaining red cells and buffy coat (white cells) or to the buffy coat alone if it is convenient to separate it from the erythrocytes. This cell mixture is agitated vigorously, and to assure thorough disintegration of the cells a few sterile glass beads are added. If the buffy coat has not been separated from the red cells the mixture must be centrifuged and the supernatant fluid removed to another sterile tube. If the buffy coat alone is used, centrifugation is not necessary as the cellular fragments do not interfere with the grafting. This fluid, whether prepared from the buffy coat or from the erythrocytes plus the buffy coat, will be referred to as 'cell extract.'

"In preparation for the actual grafting the recipient area is washed with warm sterile saline and dried with gauze. The donor area is sterilized by

whatever method the operator prefers. Thin split grafts to full thickness grafts can be used, the size of the graft being of any desired dimensions. The graft is turned upside down on a sterile piece of gauze, without washing in saline as such washing tends to remove tissue extracts which aid in producing the required coagulum. With a camel's hair brush the under side of the graft is moistened lightly with the cell extract. With another brush the plasma is painted on the recipient area. The graft is quickly fitted into the recipient area. The edges are carefully adjusted and slight pressure with the forceps is applied to the graft to assure good contact. It adheres within a few minutes. A single strip of boric acid gauze is lightly placed over the graft to protect it from infection and drying. No other dressings are applied; no stitches are needed." The Sano method, slightly modified and combined with penicillin therapy before and after grafting, has been used successfully in 120 instances by Branch et al.[101]

Skin graft fixation with plasma thrombin solution is advocated by Young and Favata,[102] who say: "The bed to receive the graft is flushed with stock plasma. Excess is to be avoided, since as fibrin is formed the fluid portion of the plasma remains. The desired grafts are removed. They should not be placed in saline solution or washed in any way since this removes the small amount of natural cohesive agents present. (It has long been noted that grafts seem to adhere and take better if this detail is considered.) The undersurface of the graft is wet with thrombin solution. The graft is quickly applied and adjusted into the desired position. It is lightly pressed in place and so maintained for a few seconds. The graft will rapidly adhere to the wound following its every contour. As fibrin forms, clear watery fluid is squeezed out. Some of this escapes from under the graft; some is undoubtedly trapped under the graft. However, as this fluid is essentially an electrolyte solution of physiologic concentration it is probably rapidly absorbed. We have not observed any ill effects from not making openings in the graft to allow its escape and thus far have not considered this necessary. It may be that the fluid is of value in the early nutrition of the transplant."[103]

Ollier-Thiersch Grafts.—Ollier-Thiersch grafts are thin slices of the epidermis, usually with a small amount of derma attached. Brown[92] says they "are too thin to be of much use in making large repairs where there must be a firm surface." It is generally desirable to employ general anesthesia for skin grafting. The skin is prepared by washing with alcohol and then with a sterile saline solution to remove all traces of the alcohol. The wound to be grafted is irrigated with sterile saline solution. The grafts will take on granulation tissue, but if it is too abundant, it should be curretted off and hot compresses applied until all bleeding has ceased. The grafts can be removed with the Padgett dermatome, but if this valuable instrument is not available, a knife can be used. The skin from which the grafts are to be taken is held tense by traction in opposite directions exerted with flat objects, such as rulers. The grafts are then removed with a razor or skin-grafting knife. This is done with a sawing motion, great care being taken not to cut through the entire thickness of the skin. A thin film of the upper epidermis only is removed. The pieces should be as large as possible. The razor or knife on which the graft lies in a wrinkled-up state is now transferred to the instrument table, and the grafts are carefully teased off the knife with the points of cambric needles onto glass slides which have been moistened with saline solution. In

this way the number of grafts are removed which are thought to be sufficient to cover the wound and are placed on glass slides. By means of the cambric needles the grafts are then slid off the glass slides onto the surface of the granulation tissue. It is important to have the graft lie smooth and flat upon the wound. No harm is done if the grafts overlap. Any curling up of the edges should be corrected carefully. When the grafts are very large, some authorities recommend the making of small holes through them for the escape of secretion. Blair attached his grafts, where possible, to the wound margins by a sort of basting stitch. This is introduced down into the graft and up through the normal skin. It is extremely important to try to prevent the lateral slipping of the graft by any movements of the overlying dressing. The grafts are then covered by several layers of selvaged fine-meshed gauze which has been throughly impregnated with a solution of 3 per cent xeroform in vaselin. The writer has found it useful to insert a number of interrupted sutures through the xeroform gauze to the intact skin surrounding the wound. This is a great preventive against side slipping of the graft. An abundant quantity of gauze is now placed over the xeroform gauze, and the whole is firmly bandaged in place. Pressure upon the grafts seems to facilitate their "taking."

The first dressing is done on the third or fourth day, and great care is exercised in the removal of the xeroform gauze, which is slowly peeled back from one edge. The edges of any grafts which have adhered to the gauze are carefully snipped off or replaced. The portion of the gauze surrounding the interrupted sutures in the normal skin may be left in place, and the fresh dressing of xeroform gauze may be anchored to this gauze by new sutures. After the grafts are a week or ten days old it will be wise to expose them to the air for several hours every day. The upper layers of the graft often scale off, but this does not interfere in any way with its usefulness.

Reverdin or *pinch grafts* are obtained by lifting the skin up with the point of a cambric needle and excising a small, round island about ¼ inch in diameter by means of a sharp scalpel or scissors. These small islands of skin are placed upon the previously prepared, clean granulations of the wound. The dressings are carried out in the same manner as those of Thiersch grafts.

Small deep grafts is the term applied by Davis[104] to grafts which are "somewhat larger than Reverdin grafts and differ from them in that they include, in addition to the epidermis, practically the entire thickness of the corium, the thickest portion being the center of the graft. The margins of the grafts are quite thin, but the thickness gradually increases so that at the center the graft usually includes the full thickness of the corium." These grafts may be removed under local anesthesia. The four main points for the successful use of these grafts, according to Davis,[104] are: "(1) The granulating surface should be healthy, clean, flat, and rose pink in color. (2) The grafts should be cut without unnecessary trauma; should usually include the full thickness of the skin at its center and should be no larger than 0.5 cm. in diameter. (3) The grafts should be placed on the surface of the granulations with an interval of 0.5 cm. between them. They should be pressed down firmly on the granulations so that the thin edges will uncurl and so that every portion of the graft will be in close contact with the granulating surface. (4) The grafts should be immobilized until the new blood supply is assured. (See Figs. 539, 540.) The grafts may be cut from an elliptical area, which is then excised and

the wound edges sutured together, as suggested by Conway.[105] Danzis, Friedman and Levinson[106] report 2 cases of carcinoma following the employment of pinch grafts. Maynard[107] believes the full-thickness pinch graft "produces the best type of integument."

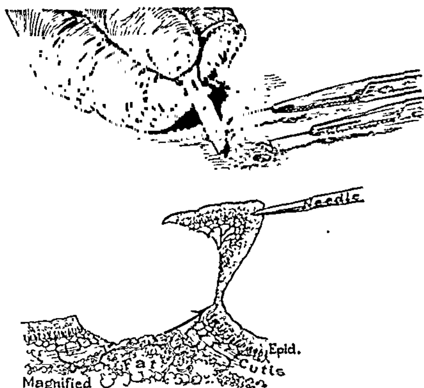


Fig. 539.—Method of cutting a small deep graft. The full thickness of the corium is included at the center of the graft, which should not be more than 0.5 cm. in diameter. (Davis, J. S : Ann. Surg. 91: 633 1930)

Thick-Split Grafts (*Split-Thickness Grafts; Thick Ollier-Thiersch Grafts*).—These grafts are one half to three quarters of the thickness of the whole skin and are considered by Brown[92] as "perhaps the most useful in making all

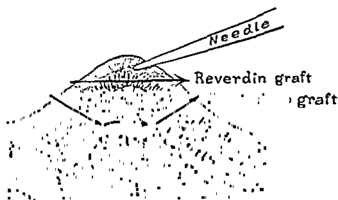


Fig. 540.—Diagram showing the relative thickness of a Reverdin graft as compared with a small deep graft. (Davis, J. S.: Ann. Surg. 91: 633, 1930.)

repairs of raw surfaces." The best method of procuring thick-split grafts is by means of the Padgett dermatome.[108] In the use of this instrument, rubber cement is applied to the skin and to the drum. The knife blade is set for the desired thickness of the graft, usually 10 to 16 thousandths of an inch, and

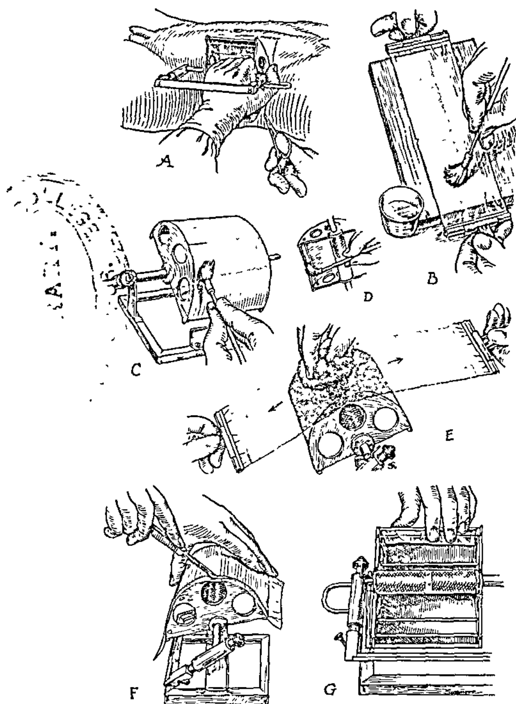


Fig 541.—Covering the dermatome drum with transparent film. *A*, Outlining the donor site around the dermatome drum. *B*, Painting the film, held at each end by broad paper clamps, with rubber cement on a board. A small notch may indicate the center of the film. *C*, Painting the dermatome drum with rubber cement. A scratch mark indicates the middle of the drum. *D*, Painting over the end and slightly inside the drum. *E*, Making the film, held between clamps, adherent to the drum. *F*, Trimming away the excess film from the edges with a scalpel *G*, Tucking in the film over the drum ends. (Webster, J. P.: S. Clin. North America 24: 251, 1944.)

as the drum is slowly rotated, lifting up the adherent skin, the graft is cut off by means of a back-and-forth stroke of the knife blade. The graft, which may be as large as 4 by 8 inches, adheres to the drum and from it is trans-

ferred to the raw area. Zintel[109] has devised a method of resplitting Padgett split-thickness grafts so that epithelization may be obtained in areas 200 to 300 per cent larger than the donor area. Adult donor skin is cut 0.020 to 0.028 inch thick, and while the graft is still adherent to the drum, the knife blade is readjusted to half the original thickness, beginning ¼ inch from the

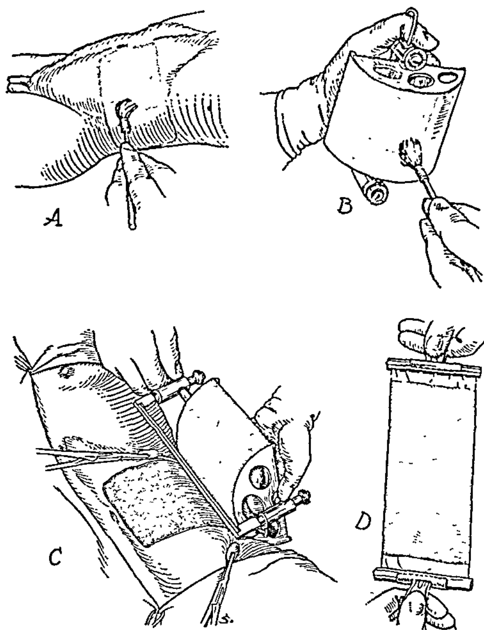


Fig. 542.—Cutting the film-cemented graft. *A*. Painting the donor area. [illegible]

edge of the graft. The graft itself is then cut in two layers. Webster[110] has developed a method of first applying pliofilm to the Padgett dermatome drum and then cutting the graft on top of it (Figs. 541, 542). This maintains normal skin tension and also prevents tearing of the graft during suturing. Hardy and McNichol[111] obtain the graft by Webster's pliofilm method and

then cut it in two pieces about the size of a postage stamp or smaller. These pieces are applied about 1 cm. apart to the granulating surfaces. The pieces of pliofilm usually come away with the dressing on the fifth day or may be removed with thumb-forceps.[112]

Brown describes the cutting and application of thick-split skin grafts as follows:

"The most essential equipment is a very sharp, long knife of the amputation variety. [illegible]

fairly large grafts may be cut even from the abdomen.

"These grafts are applied to the area after granulations have been carefully and smoothly shaved off, after any healed contractures have been fully opened by dissection, or after scar tissue has been excised. They are held firmly in place with running horsehair or 000-silk sutures all around and multiple mattressing sutures over the surface. Many stab holes are made through the grafts to provide for drainage. It is important to note that the re- [illegible]

grafts may be spread out over them and then 'snubbed' in place with a sterile fine mesh roller bandage that has been wet in saline solution. The rolls of the bandage should press the graft out firmly without wrinkling and be secured with many turns so that no displacement can occur.

"If the wound has been quite dirty originally and refractory to treatment before operation, or if there are any reasons to fear a degree of infection that might damage the graft, a wet saline dressing with irrigation tubes incorporated in it is applied and pressure is obtained over the area with sea sponges bound on firmly with heavy gauze rolls. The dressings are constantly kept moist for from three to four days after which time the first dressing is changed.

"If the area is small and quite free from contamination, a sponge pressure dressing is applied with a few layers of grease gauze over the graft instead of the wet dressing.

"On flat surfaces the bandage may be made so smooth and firm that no sponges are necessary.

"Extreme care should be taken with the dressings which are done first on the third or fourth day; the graft edges are trimmed away, sutures are removed, and some mild antiseptic is painted over the area. If there is not much cellulitis, a fine-mesh, grease (xeroform or scarlet red) gauze dressing can be used, but, if infection is present, another wet dressing should be applied."

Free, Full-Thickness Grafts.—McWilliams[114] has given excellent advice in the use of free, full-thickness grafts. Careful attention to details is necessary. By means of an inflatable rubber balloon devised by Ferris Smith, definite even pressure can be maintained over the graft until new blood vessels are formed connecting it to the underlying tissue.

"Autografts are always chosen. Fresh sterile operative wounds and fine granulating (sterile) areas are equally successful as beds for the graft Fresh fat and bones bare of periosteum are usually not suitable Free full-thickness grafts should be used in areas where contractions are to be avoided, as about the eyes and joints. The fat should be removed from the graft with a knife. Pinching of the graft is to be avoided. In order to preserve normal tension, so that the capillaries will remain open, the graft should be cut of exactly the same size as the area it is to cover. Perforations are not necessary. The graft should be sewed in carefully all about the edges with close, interrupted stitches in order to maintain [illegible]

that it facilitates their removal.

[illegible] as follows: [illegible] anted on [illegible] edle and [illegible] to 4 mm.

square—about one-half the size of a grain of wheat—and implanted deep into the granulating area about 1 to 1.5 cm. apart. Thus they are not readily removed by the oozing serum or by the change of dressings. They are held by the granulating tissues, bathed in serum and blood and not merely pressed against the surface of the granulating area. Infection of the bed is not important; they can be successfully implanted in an ulcer bathed in pus.

"If the case is bed-ridden, then the best results are obtained by continuing warm saline packs for the first few days, alternating with para-thiocresol solution as wet packs for 48 hours at a time. If the granulations are too exuberant, then apply adhesive strapping over the entire wound for 3 or 4 days. If the case is ambulatory then apply an ointment dressing to protect the granulations and change as before."[119] Barber[120] uses a large-bore hypodermic needle to inject the grafts immediately beneath the surface of the granulation tissue.

"Free full-thickness grafts are successful when applied to fresh muscle and fascia, including pericranium and periosteum, to bared sheaths of tendons, whether granulating or fresh, to palmar fascia, to fine clean granulating areas generally, except in the neck, and in the defects produced by the surgical removal of rodent ulcers."[114]

Ashley[121] has successfully employed the foreskins from infants circumcised when 7 to 10 days old. The foreskins are usually placed in saline solution and kept in the ice box until used or up to two weeks. The raw surface of the foreskin is placed on the granulating surfaces.[122] Ashley obtained 19 "takes" with 27 foreskins in one case. McCarroll[123] finds that the return of sensation in transplanted skin is inversely proportional to the thickness of the graft. The marine sponges advocated by Sumner Koch are a valuable substitute for the inflatable rubber balloon.

Hypodermic Injections.—The technic of the insertion of a hypodermic needle is very simple. The skin is first cleansed by means of a pledget of gauze

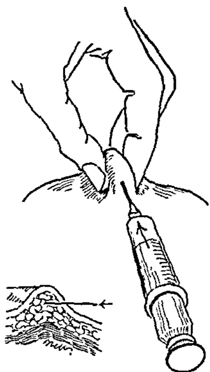


Fig. 543.—Administration of hypodermic medication. The skin is lifted up between the thumb and forefinger and is gently pinched.

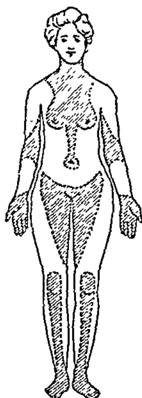


Fig. 544.—Areas of the body surface where a hypodermic should not be given. (Maisonnet, J.: Petite chirurgie, Paris, Gaston Doin et Cie, 1928.)

soaked in alcohol. The skin is pinched up between the thumb and forefinger under some slight pressure, and a hypodermic needle is firmly and quickly passed through the skin into the subcutaneous tissue (Fig. 543). Care must

be taken not to break off the needle in the tissues. This unfortunate accident has happened many times, and it is often extremely difficult to find the needle. The hypodermic solution can be injected rapidly when the point of the needle is in the subcutaneous tissues. The point should not be in the skin itself.*

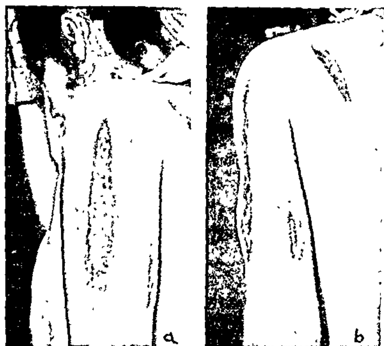


Fig. 545.—Healing incisions necessary in the treatment of a violent streptococcic infection following a hypodermic injection for hay fever. *a*, Lateral view; *b*, posterior view.

Figure 544 shows the regions in which hypodermic injections should not be made. Gas gangrene has followed therapeutic injections. (See the section on Gas Gangrene.) For results of a violent hemolytic streptococcus infection following a hypodermic injection for hay fever see figure 545. Demme[124] reports 5 cases of injury to the sciatic nerve after intragluteal drug injections.

Blood Transfusion.[125]—The indications for blood transfusion are numerous. In discussing these indications Rolleston[126] says that blood transfusions are of value to make good the deficiency of blood after acute hemorrhage, to increase the coagulability of the blood by supplying fibrinogen, to make good a deficiency of red blood cells, to furnish substances in which the blood is deficient, such as antibodies in acute infections and functionally active hemoglobin in carbon monoxide poisoning, to act upon the bone marrow which is disordered, as in leukemia, to dilute toxins in toxemia and to increase the bactericidal power of the blood through the action of leukocytes and the opsonic power of the serum. It is to be considered in acute anemia due to hemorrhage, chronic anemia due to repeated hemorrhage, hemorrhagic diseases and conditions, purpura hemorrhagica, postoperative shock, hemorrhagic diseases of the newborn, hemophilia, jaundice, pernicious anemia, anemias other than Addison's anemia, leukemia, acute septicemia, intoxications such as carbon monoxide poisoning, and debility. In reviewing 25 cases of blood transfusion done in cases of septicemia and pyemia, Keynes[127] found there was no benefit in 22 cases. Burkle-de la Camp[128] says that sur-

*The Huber point (Becton, Dickinson & Co.) for hypodermic needles is useful.

gical treatment of the source of the generalized infection and of the purulent metastases is always necessary as blood transfusion has no direct effect upon encapsulated foci or progressing phlegmonous processes. It has been recommended for children in cases of inanition malnutrition and secondary anemia from such causes as chronic gastrointestinal infections, diarrhea, chronic bronchitis, unresolved pneumonias (Brooks[129]) and even erysipelas (Sidbury[130]). Mosenthal and Ashe[131] recommend the transfusion of blood in Bright's disease for the relief of the progressive secondary anemia accompanying impairment of renal function. According to Krizevski,[132] blood transfusion is indicated only in certain types of tuberculosis. These include pleurisy with effusion, peritonitis, polyserositis, adenopathies and focal pulmonary tuberculosis. It is contraindicated in fibrous tuberculosis and sclerosis of the lung.

Death after transfusion is mainly due to the fact that the elimination of the foreign substances overtaxes certain organs, such as the kidneys, liver, heart and vessels, and causes insufficiency.[133] The danger of thrombosis or of embolism following transfusion is not great provided the technic is faultless. Zukerman[134] found that among approximately 285,000 venipunctures performed at the Blood Donor Center in Chicago, there were 12 cases of thrombophlebitis in the cubital veins following venesection. Of these, 11 were in females and 1 in a male. The most important predisposing factors are listed as trauma to the vein wall and slowing of the blood flow by means of (*a*) the application of a circular bandage, (*b*) hematoma, (c) systemic reaction and (*d*) acute flexion of the forearm or straining of the arm during exercise following venipuncture. Disability following thrombophlebitis of the cubital veins averaged approximately four months. Other authors report that in some cases death was caused by dilatation of the heart. Transfusion fatalities are more frequent in diseases of the blood and during sepsis than in acute hemorrhages. Still under discussion is the relation between agglutination and hemolysis. If hemolysis may take place without preceding agglutination, then it would be necessary in the preliminary tests to give more attention to hemolysis than has previously been done.

It is important that the donor have a negative Wassermann or Kahn reaction. Juries have returned verdicts against doctors who have made a transfusion without a Wassermann test. Rein, Wise and Cukerbaum[135] advise the Kline flocculation test, because of its ease and rapidity. The blood donor need not be in the active phase of syphilis to transmit it.[136] Syphilis has been transmitted by transfusing blood from a syphilitic donor in a good many cases.[137] According to Rein, Wise and Cukerbaum[135] 68 proved cases of syphilis transmitted by blood transfusions have been reported, but the actual number must be much greater. The chancre is absent, and the appearance of the secondary eruption usually leads to the diagnosis. The incubation period is two to two and one-half months.[138] Eichenlaub and his associates[139] recommend that when there is insufficient time to investigate the donor for syphilis, 0.01 Gm. of mapharsen be added to the sodium citrate solution when the blood is withdrawn from the donor.[140] Flaum[141] reports the case of a professional donor who in two months inoculated 4 subjects with malaria. Some 35 cases of accidental transmission of malaria through the administration of blood had been reported up to 1941.[142] The return of military personnel from malaria-infected areas has greatly increased the possibility

In 1938 Goodall, Anderson, Altimas and MacPhail[169] described placental blood as an "inexhaustible source" of blood for transfusions. The emptying of the placenta of blood does not interfere with its separation. This method was first described by Bruskin and Farberova,[170] of Moscow and later by Stavskaya,[171] of Kiev. Goodall *et al.* recommend the following preservative, which was proposed by the Moscow Institute of Hematology:

Sodium chloride	7.0	Gm.
Sodium citrate	5.0	Gm.
Potassium chloride	0 2	Gm.
Magnesium sulfate	*0 004*	*Gm.*
Bi-distilled water	1,000 0	cc.

They say: "This solution* is now put up in ampuls of 25 cubic centimeters which, when added to 100 cubic centimeters of distilled water, gives one the proper dilution, so that preservative and blood from each case is mixed in equal proportions, 125 cubic centimeters *of preservative and roughly 125 cubic centimeters of fetal blood.*" The blood is properly grouped, tested for syphilis and stored in glass flasks at 33 to 38 F. An average of 50 cc. is obtained from each birth.

The "*blood bank*" is a procedure developed at the Cook County Hospital, Chicago, for collecting and storing blood under proper refrigeration until required for transfusion.[172] This plan is applicable only to larger hospitals. All hospitals should organize a blood transfusion service and blood donor bureau. Scudder, Drew, Corcoran and Bull[173] have shown that "there is a daily increase in the plasma potassium of preserved blood kept under aseptic, bacteriostatic conditions with increments reaching as high as 1,000 per cent." They say: "In pathologic states associated with potassium retention or sensitivity, the use of blood preserved too long seems ill advised."[174]

In a review of the experiments in the transfusion of the blood of animals to man, Cru- [illegible]

Kunz[176] reviewed the subject of transfusion with the blood of animals and came to the opinion that heterologous blood is suitable for transfusion into human beings after careful testing for agglutination and hemolysis.

Blood Typing.—The first requirement for blood transfusion is to obtain a *donor whose blood is compatible with that of the patient. The bloods of the* donor and recipient should be grouped or typed; if they fall in the same group, a compatibility test is then done, and if this in turn is satisfactory, the transfusion may be carried out. Grouping has the additional advantage that, at leisure, prospective donors may be grouped, so that when a transfusion is desired, it will be easier to find the proper type of donor.

At the present time some confusion exists as to the nomenclature with regard to blood groups. The following table, after Kennedy,[177] shows the correlations of the different blood classifications:

Jansky	"New" Landsteiner (International).	Moss
I	O	IV
II	A	II
III	B	III
IV	AB	I

According to Tiber,[178] the Hygiene Committee of the League of Nations has accepted the Landsteiner nomenclature. Kennedy[177] says that "about

* This preparation is manufactured by Ayerst, McKenna & Harrison, Montreal, under the name "citro-seroid."

three-fourths of the hospitals that do blood grouping are still using the Moss classification" and that this classification should be adopted by all institutions in this country performing blood grouping. Monroe[179] found the distribution of Moss groupings in 96 patients at the Evanston (Illinois) Hospital to be I, 0; II, 43; III, 11; and IV, 42.

The tests should be made the same day as the transfusion. The importance of the compatibility test is evident from Cornils' study of 500 blood transfusions. In 5 per cent of this author's cases the preliminary serologic tests were found to be incorrect.

The technic for blood typing and compatibility used at the Evanston (Illinois) Hospital is the Brice modification of the macroscopic porcelain plate method. It is described by Dr. E. L. Benjamin as follows:

"Five cubic centimeters of blood is withdrawn with a syringe and needle from the median basilic vein in the usual manner from the recipient (patient) and from the prospective donor. Three drops of blood from a 20 gauge needle is placed in 4 cc. of a physiologic saline solution containing 2 per cent sodium citrate. This serves as a cell suspension. The remainder of the blood is put into a 15 cc. centrifuge tube and allowed to clot. After centrifugation the supernatant clear serum is used for compatibility and serologic tests.

"A Coors porcelain spot plate is used for the test. Into each of the first three hemispheric concavities, 0.1 cc. of pooled type serum is placed.

Type	II (Moss) is placed in concavity No.	1
"	III " " " " "	" 2
"	IV " " " " "	" 3

To each o' these is added 2 or 3 drops of the red blood cell suspension to be typed. Fifteen minutes is the minimum time permitted to elapse before the reading is recorded (Fig. 546), although agglutination or clumping usually occurs in a few minutes. The plate is then lifted with the hands and the cell suspension-serum mixture is thoroughly mixed by oscillating and rocking the plate for se...

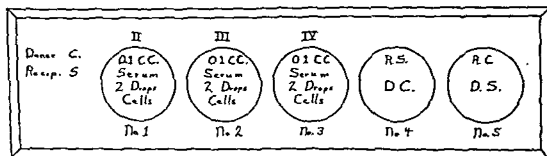


Fig. 546.—Diagram of Coors' porcelain spot plate showing use in blood grouping. (Monroe, S. E.: Am. J. Surg. 45: 36, 1939.)

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"Compatibility to c
the donor's cell suspe
R.S -D C. Two parts
are placed in concav ... labeled R.C.-D.S. These mixtures are appropriately mixed. If at the end of thirty minutes no clumping of the cells has occurred in either preparation, the bloods are *compatible. If at* any time clumping occurs in R.S.-D.C. or in both concavities, the bloods are incompatible.

"Advantages of this method.—*Rapidity* of performance. Six tests may be performed at the same time, including typing and direct matching. Absence or presence of clump-

ing is noted with ease and certainty. During the past year 1,722 tests have been performed with this method without error."[179]

Moss Classification of Blood Groups

Cells	Serum II	Serum III	Serum IV
I	x	x	x
II	o	x	x
III	x	o	x
IV	o	o	o

x agglutination o no agglutination

Cameron[180] decries the method of direct cover-slip matching and the use of the so-called "universal donor." Hesse[181] learned of 46 cases of hemolytic shock following the transfusion of "universal donor" blood, 20 of which were fatal. He concludes that there is no true universal donor and that if in an emergency such a donor is used, no more than 200 cc. should be given. After typing the bloods, Cameron advises the Breslich modification of the Landsteiner test tube method of determining compatibility. Cameron says: "Ten test tubes are arranged in numerical order in a rack. Into each of tubes 1, 2, 3, 4 and 5 is placed 0.1 cubic centimeter of a 5 per cent saline suspension of the donor's erythrocytes. To each of tubes 1, 2 and 3 is added the recipient's serum in the following amounts respectively: 0.1, 0.2 and 0.4 cubic centimeters. Four-tenths of a cubic centimeter of the donor's serum is added to tube 4 Into each of tubes 6, 7, 8, 9 and 10 is placed 0 1 cubic centimeters of a 5 per cent saline suspension of the recipient's erythrocytes To each of tubes 6, 7 and 8 is added the donor's serum in the following amounts, respectively: 0 1, 0.2 and 0.4 cubic centimeters. Four-tenths of a cubic centimeter of the recipient's serum is added to tube 9 Physiological saline solution is added to the 10 tubes in amounts sufficient to make the content of each equal to 1 cubic centimeter. In tubes 1, 2, 3, 6, 7 and 8 occur the cross reactions between the serum of both the donor and the recipient in three different dilutions and their erythrocytes. In tubes 4, 5, 9 and 10 occur control reactions between serum and erythrocytes of the same origin in saline solution and between the saline solution and the erythrocytes alone of both the donor and the recipient.

"Blood in the amount of 10 cubic centimeters is withdrawn for the examination. To 2 cubic centimeters are added potassium oxalate crystals to prevent clotting The serum from the remaining portion is recovered after separation from the clot. The oxalated blood is centrifuged and the cells removed. They are washed in physiological saline solution three times to rid them of serum. The final packed cell mass in the centrifuge tube is converted into a 5 per cent suspension by the addition of physiological saline solution.

"After preparation, the tube mixtures are allowed to stand for 1½ hours Delayed reactions are not uncommon. Incompatibilities, if present, are usually apparent within 40 minutes but, for absolute safety, the full 1½ hour observation period is necessary In approximately 4 per cent of tests between bloods of the same group incompatibility is found which is usually due to agglutination but occasionally to hemolysis. If the macroscopic evidence of agglutination is at all doubtful, a rare event, a microscopic examination is carried out.

"This test tube method has been relied upon at Trinity Hospital for all of the more [illegible] l no reac-

[illegible] mparable

[illegible] grouping.

[illegible][184])

Reactions after blood transfusion are often dependent upon factors other than the blood grouping. According to Zimmerman and his associates[185] transfusion reactions may be classified as pyrogenic, allergic, and hemolytic. Pyrogenic reactions constitute the largest number of post-transfusion reactions. They are characterized by fever, with or without chills. They are almost invariably due to the presence of foreign contaminants in the solutions or apparatus. Sepsis and blood dyscrasias predispose to pyrogenic reactions.

Allergic reactions are usually urticarial in nature. The chief causes are donors with allergic tendencies and donors who have eaten shortly before giving blood. Patients with ulcerative colitis seem to be predisposed to allergic reactions. Hemolytic reactions are usually due to the administration of incompatible blood. This can be avoided only by careful preliminary typings and reciprocal crossmatchings, the use of high-titer testing sera, and the rejection of all bloods giving questionable agglutinations.

Universal-donor blood gave no higher incidence of reactions than did blood of homologous groups. Malkiel and Boyd[186] report: "A case of transfusion reaction due to the use of a dangerous (high titered) universal donor was observed in which the recipient lost nearly 30 per cent of her original red cells as a result of the transfusion but ultimately recovered." Klendshoj and Witebsky[187] have recommended the addition of the purified blood group specific substances A and B to group O blood with potent isoagglutinins to overcome its use as a universal blood.[188] In 1,000 transfusions Zimmerman and his associates[189] classified the reactions as follows:

	Number of Transfusions	Pyrogenic Reactions	Allergic Reactions	Total Reactions
Patients and donors of same blood group..	780	35 (4.5%)	12 (1.5%)	47 (6.0%)
Patients and donors of different blood group	220	5 (2.2%)	3 (1.4%)	8 (3.6%)
Total..................................	1,000	40 (4.0%)	15 (1.5%)	55 (5.5%)

Reactions in blood transfusions may also occur because of the presence in the blood of the donor of the *Rh factor* when the blood of the recipient contains no Rh factor (Rh negative) but does contain anti-Rh agglutinins and hemolysins which have become present either by repeated Rh positive transfusions or by the presence in an Rh negative pregnant female of an Rh positive fetus. Fifteen per cent of the population is Rh negative. McGraw et al.[190] say that "approximately 13 per cent of the white, 6 per cent of the Negro race and 1 per cent of the Chinese are Rh negative." The blood of Rh negative and Rh positive individuals may be in the same group and compatible when the test is made at room temperature. When, however, the test is made in the incubator over a half hour, it is said that the incompatibility due to the admixture of Rh positive blood and blood containing anti-Rh agglutinins and hemolysins will be disclosed. Anti-Rh agglutinins and hemolysins may be found in a woman's blood for four to six months post partum. The Rh factor is an antigenic substance in human red blood cells and is inherited as a mendelian dominant. It was first described in 1940 by Landsteiner and Wiener.[191]

Tisdall and Garland[192] say: "The present day knowledge of the importance of the Rh factor to the clinician, particularly the obstetrician, the pediatrician and the transfusionist, makes imperative the determination of its presence or absence in a large number of persons. Certainly no premarital, antepartum or pretransfusion examination is complete without an Rh testing. Using a high titered human antiserum with a high avidity index, the slide technic has been most satisfactory for large scale Rh testing. The ease with which Rh testing can be performed on a large scale should place it in the category of a routine test." Butler and his associates[193] emphasize that

"under no circumstances should obstetrical patients be transfused with Rh positive blood unless the patients have been tested for the Rh factor."[194]

After an experience with more than 12,000 blood transfusions, Hoxworth[195] concludes that transfusion accidents can largely be prevented by attention to the following principles: (1) For grouping, only *test serums of high titer should be used*. Few laboratory technicians know the titer of their test serums,

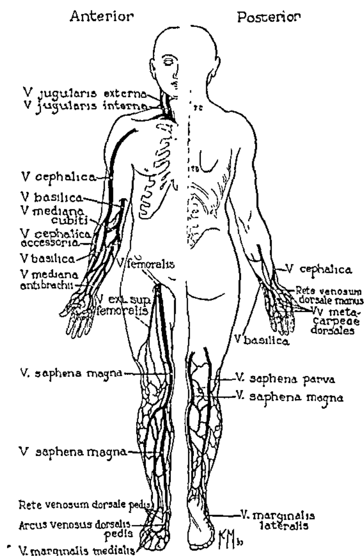


Fig. 547.—The superficial veins used in blood transfusion, for purposes of uniformity in the record. (Lundy, J. S : S. Clin. North America 14: 721, 1934.)

but determinations may be made by the Coca[196] method or by the method of serial titration.[197] (2) The use of a group IV0 donor for a group I (AB) recipient. Death has resulted because agglutinin in the serum was of unusually high titer. (3) Close observation of the patient during the transfusion. Early, mild subjective complaints or objective signs are indications for discontinuing a transfusion. (4) Rejection of compatible donors by misinter-

pretation of false agglutinations. False agglutinations can be distinguished by the direct match-test with open technic on a slide and stirring to break up the clumps under the microscope. In true agglutination, stirring produces a more marked agglutination. Moreover, simple saline solution may cause a false agglutination. (5) Performance of compatibility tests before all transfusions, even though the blood is of the same group. (6) Consideration of Rh factors.[198] (See previous discussion.)

Transfusion of red cells suspended in saline solution is often valuable and may be recommended from the economic standpoint.[199]

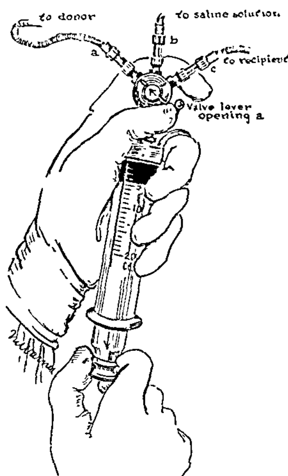


Fig. 548.—Whole blood transfusion with the Scannell apparatus.

According to Tiber,[178] the death rate for blood transfusions is 0.39 per thousand.

Technic of Blood Transfusion.—Two general types of blood transfusion are in use. The first is the *direct* or *whole blood* method, in which the untreated blood of the donor is transferred to the recipient. The second is the *indirect* method in which the blood of the donor is first treated with sodium citrate or some other agent to prevent clotting before it is administered to the recipient. The indirect method is used far more commonly than the direct met od. See figure 547 for a diagram of the superficial veins used in blood transfusion.[200] (See also sections on phlebotomy and intravenous infusions.) The veins of the dorsum of the hand are usually the most comfortable to use for the recipient. If the wrist is flexed the needle will enter these veins more

readily. It is important that nerve trunks should not be injured either by direct contact or by infiltration. In infants the blood may be introduced into the longitudinal sinus through the anterior fontanel or the external jugular vein or by cutting down on an arm vein.

(a) *Whole Blood Method.*—Whole blood may be given intravenously and subcutaneously. In infants and very young children the subcutaneous method is occasionally used, but it is inferior to the intravenous method as the blood

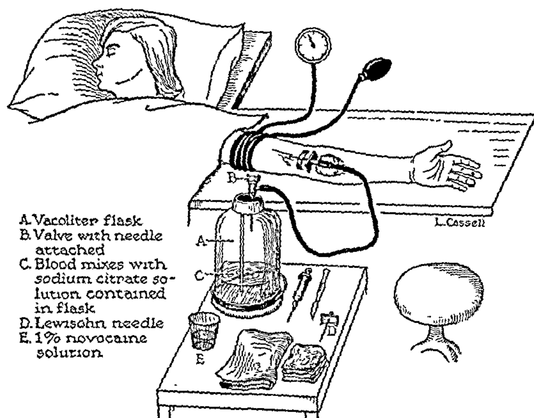


Fig. 549.—Commercial vacoliter flasks such as the one shown in this illustration have greatly simplified the withdrawal of blood from a donor. The rubber stopper is covered with an air-tight rubber disc to preserve the vacuum. The special needle, which is attached to the valve mechanism, is passed through this rubber disc after being connected with the rubber tubing. After the needle is inserted into the donor's arm, the valve is carefully opened and regulated so as to produce a brisk, steady flow of blood. When the desired amount of blood has been taken, the valve needle is withdrawn, the air-tight rubber disc is peeled off and the tube to the recipient (which contains the metal filter) is connected with the flask by the insertion of a glass tip in the rubber stopper. The flask is then inverted and suspended from a standard at a height to insure flow by gravity. (From Jennings, W. K., in Christopher, F.: Textbook of Surgery, ed. 4, Philadelphia, W. B. Saunders Co., 1945, p. 1430)

cells are lost. In this method typing and matching are unnecessary. According to Moore and Dennis,[201] the optimum amount of blood for newly born and dehydrated infants is 50 cc. per kilogram of body weight, or 5 per cent. The necessary percentage decreases with age. The blood should be given subcutaneously in the thighs and in the sides and front of the chest and abdomen. (For intraperitoneal injections see Grulee,[202] Florey and Witts[203] and Ravenel.[204])

Perhaps the best method of giving a whole blood intravenous transfusion is by the use of the *Scannell apparatus.* This consists of a three-way valve connected to three rubber tubes and to a 20 cc. specially constructed syringe. The rubber tubes go to the donor, the recipient, and to a basin of saline solution (Fig. 548). The patient and donor are placed upon parallel operating tables with the arms to be used extended on arm-boards, so that the wrists of the two individuals lie side by side. It is usually possible to use large needles for both donor and recipient, but in some instances a cannula will be required for either one or both. It is important to maintain a gentle flow of saline solution when blood is not going in. The syringes used for blood should be changed and washed after each two or

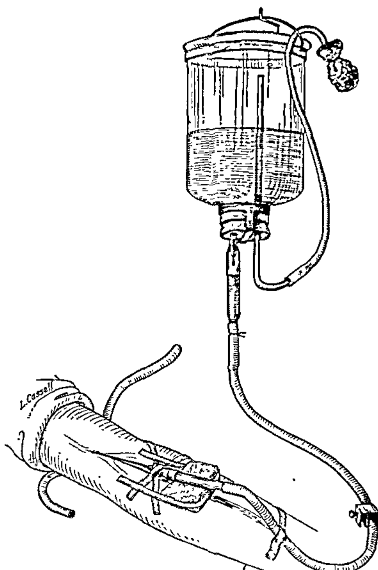


Fig. 550 —Vacoliter flask in indirect blood transfusion. (Monroe, S. E.: Am. J. Surg. 45: 36, 1939.)

three fillings to prevent sticking. Proper manipulation of the three-way valve and the syringe pistons will quickly withdraw 20 cc. of blood at a time from the donor and deliver it into the vein of the recipient.

Another method of whole blood

, and is attached to

While the blood is

of the recipient, a second syringe is attached to the donor's needle,

and 50 cc. more of blood is being withdrawn at the same time. When the blood has been injected into the vein of the recipient, the syringe is detached from the needle and handed to a nurse, who will thoroughly wash the syringe and piston with saline solution and see that it is in proper working order. A freshly cleansed syringe is always used for the withdrawal of blood from the vein of the donor. Four to six syringes are used in this method. Clotting is more liable to occur in this method than in the Scannell method. Several other methods of whole blood transfusion have been devised, including the Unger method and the method of Head.[205] In the latter method a specially designed valveless pump keeps the blood in motion. Stout[206] has used the Head transfusion pump in 200 transfusions and *believes that it "provides a very simple and safe method of whole-blood transfusion."* Direct anastomosis between the artery of the donor and the vein of the recipient is no longer employed. Brooks[207] has described a useful modification of the Kimpton-Brown method. The very simple valve attachments for syringes to be used in blood transfusions have been described by Gillentine and de Bakey[208] and by Hirsch.[209]

(*b*) *Indirect Method.*—In this method the blood of the donor is withdrawn through a short connection and immediately mixed with the desired quan-

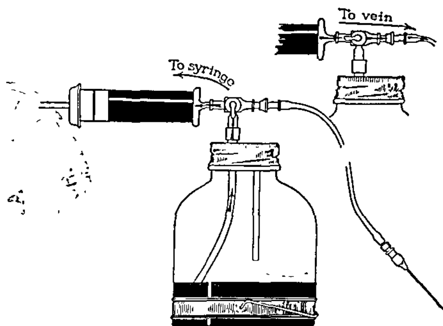


Fig. 551.—Transfusion apparatus for infants. (Baird, J. W.: Proc. Staff Meet., Mayo Clin. 19: 256, 1944.)

tity of sodium citrate or some other solution. The citrate method was originally described by Lewisohn.[210] For every 10 cc. of 2 per cent sodium citrate solution, 90 cc. of blood is added, making a 0.2 per cent solution, or 2 grains to the liter. As the blood is mixed with the citrate solution, clotting is prevented. The citrated blood may at leisure be injected into the vein of the recipient even after several days, if kept in an ice box. Generally it is preferable to inject the citrated blood at once. This is especially true when the citrated *whole blood or plasma is given rapidly."* If the veins are collapsed, the citrated blood may be given in the sternum or, in a child, in the tibia. (See Sternal Infusions.) In intravenous transfusions in infants where a small amount of pressure is desired to force the blood through the small-gauge needle, the apparatus devised by Baird[211] is useful (Fig. 551). A method of withdrawing blood from a donor is shown in figure 549. Figure 550 shows the use of a "vacoliter" flask in the indirect method of blood transfusion.[179]

Heparinizing the donor in order to deter clotting has received attention. Hedenius,[212] in 150 transfusions, has used 1 mg. of heparin per kilogram of body weight of the donor and has administered the blood within thirty minutes by means of syringes or any other method. A sterile 5 per cent heparin solution containing 0.25 per cent tricresol is used.

Plasma and Serum Transfusions.—The exigencies of war directed great attention to the subject of blood substitutes, particularly human blood *plasma* (the fluid portion of the blood obtained before clotting has occurred) and human blood *serum* (the fluid portion of the blood obtained after clotting has occurred). Plasma is indicated particularly in cases of shock and of burns. If shock is accompanied by hemorrhage the plasma should be followed by whole blood. Churchill[213] says: "Plasma is looked upon as a first aid measure for dire surgical emergencies, not a safe or satisfactory therapeutic agent for hemorrhage. It is a supplement, not a substitute, for whole blood. Specific indications for its usage are found in the management of burns and a few other conditions in which only the plasma is lost from the circulation. Even in these instances, it appears that objections to the employment of whole blood have been exaggerated."[214] Plasma is also indicated in the hypoproteinemias, hemorrhagic diseases, cerebral edema and infections in which whole blood is also given if anemia is present. According to Strumia and McGraw,[215] plasma causes no reactions (except rare instances of mild urticaria) and may be given in much larger quantities than blood.[216] Levinson and his associates[217] prefer serum to plasma "because it does not contain sodium citrate and because fibrin precipitates do not occur."[218]

The committee on transfusions and the subcommittee on blood substitutes of the National Research Council together with representatives of the Army and Navy concluded that dried plasma, because of its therapeutic effectiveness, ease of preservation, long period of storage and safety of administration, was the blood derivative of choice for use by the armed services. It was also concluded that freezing and maintaining it in the frozen state was an adequate method for storage of plasma for an indefinite period, either as a preliminary stage to drying from the frozen state, or for direct use after rapid thawing.[219]

Dehydration of the plasma is accomplished by means of the lyophile technic of rapid freezing and removal of water vapor under high vacuum. The desiccated material derived from 250 cc. of fresh, pooled plasma is sealed under vacuum, and restoration is quickly achieved by the addition of sterile, pyrogen-free distilled water from a companion bottle. Morever, hypertonic (concentrated) plasma can be easily prepared when necessary.

In consideration of field requirements, a rubber closure was adopted for the standard package of normal human plasma. The plasma bottle is sealed under vacuum in a metal can, together with the intravenous injection needle, clamp and double-ended needle (used for restoring the dried plasma). The rubber-stoppered bottle of pyrogen-free distilled water as well as the intravenous injection set and air filter are sealed under an atmosphere of dry nitrogen in a second metal can of the same size. Complete instructions for restoration and use are stencilled on the plasma can. For a description of the standard package of dried plasma for the Army and Navy, the article by Strumia and his associates[220] should be consulted. Similar packages can be obtained commercially for civil medical practice.

Concentrated or hypertonic plasma is advocated by Muirhead and his col-

leagues.[221] In a review of certain blood substitutes, Henderson[222] concludes "that, taking all factors into consideration, plasma is the most satisfactory blood substitute available at the present time. Desiccated plasma is superior to liquid plasma for use under military and other mobile emergency conditions . . . It is of no less value in civil practice since it is the most stable form of plasma available." Ivy and his associates[160] say: "It is believed (*a*) that the citrated human plasma now available for use should be accompanied by the precaution that it be injected slowly and not in unlimited quantities in patients who have suffered a massive hemorrhage; and (*b*) that the label should carry a statement regarding the toxicity of sodium citrate." (See citrate transfusions.)

From a careful analysis of extensive data, Thalhimer[223] concludes that in pools of plasma or serum, agglutinins are reduced to such a low level "that no danger can result to patients from the injection of even large doses of these pools." Large amounts of pooled plasma are given safely without any preliminary tests for compatibility. Hill and Muirhead[224] say that "although plasma prepared by pooling after separation of erythrocytes carries very little risk, greater safety can be obtained by pooling of blood of all different types prior to separation."[225]

Plasma may be administered by vein or in the bone marrow, as described in the section on blood transfusion.

Sternal Marrow Aspiration (See also Sternal Infusions).—A study of the bone marrow is often of first importance for a complete understanding of the various blood dyscrasias. Arinkin[226] pointed out the availability of the sternum for studies of the bone marrow. The apparatus (Fig. 552) and method of Gradwohl[227] are of value for this purpose. In describing the apparatus, Gradwohl says:

"It consists of a 10 cc. Luer Lok syringe, a cannula and connector with a rubber tubing joint, a bone marrow puncturing instrument with a guard which can be adjusted to fit the depth of the sternal puncture and an obturator for the latter.

"The skin over the sternomanubrial junction is surgically prepared, the usual sterile dressings are applied and local anesthesia with procaine hydrochloride solution is injected intradermally, subcutaneously and into the periosteum. The instrument for puncture has a handle which permits a firm grasp and allows one to bore through the external lamina of the sternum and enter rapidly the marrow cavity of this bone. The instrument is thrust [illegible]

[illegible] well penetrated the sternum, the direction is changed with the point directed upward. At [illegible]

[illegible] of course, that the entire instrumentarium must be adequately sterilized before use. One may place a small amount of dilute sterile sodium citrate solution in the barrel of the syringe, [illegible]

"It is not necessary to remove a large quantity of bone marrow. Only a small amount is obtained, usually about from 0.2 to 0.3 cc. Touch preparations are made on the surfaces of clean, fat-free glass slides. A few smears also are made. The Giemsa is the best staining method. The specimens are dried in the air and fixed with methyl alcohol. The specimens are stained for thirty minutes with a dilute Giemsa stain made by taking a drop

...er. After the staining
dried in the air and
examined.

Biopsy is the diagnostic examination of a piece of tissue excised from the living subject. Usually biopsy should not be performed unless the surgeon has facilities to have the tissue examined by the pathologist grossly or microscopically while the patient is on the operating table and is prepared to proceed immediately with the radical operation if the tissue examined reveals a malignant growth. The tissue to be examined is removed under local or general anesthesia. In experiments on rats Maun and Dunning[229] found no

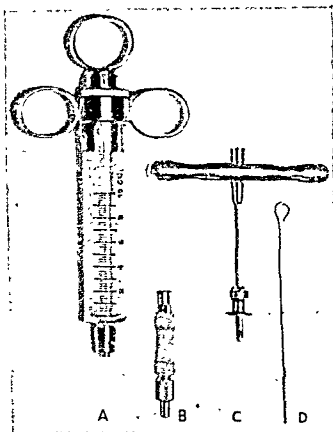


Fig. 552.—The entire set-up for the procedure of procuring sternal bone marrow material: *A*, Syringe; *B*, cannula and connector; *C*, bone marrow puncturing instrument; *D*, obturator. (Gradwohl, R. B H.: J. A. M. A. 108: 803, 1937; instrument made by A. S. Aloe Co., St. Louis.)

untoward effects from cutting into the tumor mass or from severing lymphatic channels. Coley, Sharp and Ellis[230] say that "biopsy by the aspiration method is of value in establishing the diagnosis of bone tumors." Martin and Ellis[231] report 1,405 positive diagnoses of cancer by aspiration biopsy at the Memorial Hospital in New York. Some surgeons vigorously condemn the practice of making punch biopsies.

Martin and Ellis describe their technic as follows: "The special instruments required are an ordinary 18 gauge needle, 5 to 10 centimeters in length (which should be new or recently sharpened) and a 20 cubic centimeter record syringe Needles of about 15 to 20 centimeters in length are sometimes required for aspiration at greater than average depths,

as for instance in the lung or prostate. Glass slides are necessary for smearing the specimen, and a specimen bottle with 10 per cent formalin, if a portion of the tissue is to be treated as a regular biopsy.

"The skin at the site of the intended puncture is painted with iodine, and a small area of skin infiltrated with 1 per cent novocain. In particularly sensitive regions, some of the local anesthetic is injected continuously along the line of the intended puncture, down to the tumor. With a bistoury pointed scalpel (No. 11 Bard Parker blade), a stab wound is made through the skin with the instrument held at right angles to the skin surface. This puncture of the skin facilitates insertion of the needle and prevents contamination of the aspirated material by surface epithelium. An 18 gauge needle attached to a tightly fitting record syringe (with the piston closed) is then inserted and advanced slowly through the superficial tissues until the point is felt to enter the suspected neoplastic mass. Guided by palpation with disengaged hand, it is striking how readily a difference in consistency of the tissues can be felt, as the point of the needle enters a mass of neoplasm. When the point of the needle is felt to enter the tumor, the piston of the syringe is partly withdrawn so as to produce a vacuum, and the needle is then advanced 1 to 3 centimeters further, depending on the anatomy and size of the tumor. Maintaining the vacuum, the needle is then withdrawn to the same distance, advanced again, and withdrawn, thus maintaining the vacuum constantly and keeping the point of the needle within the tumor. Tissue from the tumor mass enters the needle and is held within it both by a punch action of the advancing needle and by suction of the vacuum. *Care must be taken that the vacuum is maintained while the needle is manipulated within the tumor. Aspiration by suction alone, with the needle at rest, is not sufficient to draw tissue into the needle, in most cases, and is the most common cause of failure to secure tissue.*

"Before the needle is completely withdrawn from the tissues, the piston must be slowly released, the syringe detached, and the needle withdrawn separately, otherwise any remaining vacuum may cause the aspirated material to be suddenly drawn into and splashed over the interior of the syringe, making its collection more difficult. If the tumor is fairly firm in consistence, blood and tissue usually do not appear in the syringe, but the needle will be found to contain material. In soft and vascular tumors, a small quantity of blood mixed with fragments of tissue may enter the syringe while the needle is being advanced and withdrawn, or a solid cylindrical mass of tissue may appear.

"After complete withdrawal of the apparatus, the syringe is partially filled with air, again attached, and the contents of the needle slowly and carefully expelled on to a glass slide. If there is much resistance to expelling the plug of tissue from the needle by the air filled syringe, it is safer first to push part of the tissue out of the needle with the wire obturator, otherwise, with great pressure, the plug may suddenly pop out and be lost. If only a smear of the specimen is desired, any excess of fluid or blood is carefully blotted off with gauze and a second slide placed over the first, and with *firm pressure* crushed very thin and drawn once across lengthwise."

These authors say: "*Aspiration biopsy* has, we believe, few if any of the objections of surgical biopsy in tumors below the surface of normal tissue. The risk of dissemination of metastases through the tiny break in the capsule, such as will be caused by an 18 gauge needle, is comparatively slight. We have not observed any alteration in the clinical setting in any of the cases herein reported. The procedure is accepted casually by the patient as part of the routine examination. It can be done in a few minutes with little discomfort, if novocain is judiciously distributed along the more sensitive portions of the proposed needle puncture. No hospitalization is required and the procedure can be done in any clinic or office without any special preparation or apparatus, except an ordinary 18 gauge needle and record syringe."

Hoffman[232] describes an instrument which he has used in making 100 *punch biopsies* at the Memorial Hospital in New York. He says: "The action of the instrument is safe,

[illegible]

diagnostic purposes.

For a report on liver biopsy, the article by Beierwaltes and Mallery[235] should be consulted, and for prostatic biopsy, the article by Roth and Turkel[236] will be found to be informative.

Plaster of Paris Technic.[237]—Suitable types of plaster of paris bandage to use are those which are properly made in hospitals. The powdered plaster of paris is thoroughly insinuated between the wide meshes of crinoline bandages by means of an appropriate machine. It is a matter of experience as to the quantity of plaster to use and the degree of tightness with which the bandages should be rolled. The commercial plaster of paris bandages may be purchased in tin cans.[238] The addition of a small quantity of sodium chloride to the water in which the bandages are soaked will shorten the time required for their setting, but it is generally unnecessary. The manner of immersion of plaster bandages varies according to the technic employed by various surgeons. Some prefer to immerse the bandage wrapped up in a tissue paper cover, so as to prevent possible loss of plaster. The removal of the tissue paper, however, is time taking and impracticable. The best method is to place the uncovered bandage gently in a pail of tepid water and to allow it to soak until no more bubbles arise from it. The bandage is then carefully removed from the water and is grasped at either end. Compression is then made so as to squeeze the bandage together in an end to end manner to remove the excess water without losing more than necessary of the plaster of paris (see Fig. 349).

For the application of plaster of paris, if possible, the skin of the affected site should be cleansed carefully with soap and water, and with alcohol and dusted with talcum powder. An adequate length of stockinet then should be rolled upon the extremity in the manner described previously. The stockinet is then covered with cotton sheet wadding to the thickness desired. Where there are bony prominences, these should be covered with appropriately shaped felt pads, the edges of which should be beveled. (Fig. 553.) The wet plaster bandage is then carefully and smoothly wound around the portion of the body to be enclosed in the cast. A moderate uniform tension is kept upon the bandage, and all wrinkles are avoided. There should be no reverses in the first layer of the bandage, as they might exert pressure.[239] As the layers of bandage are applied they should be *constantly rubbed* with the hand to insure the thorough filling of the meshes of the bandage with plaster of paris. It is important that the extremity enclosed in the cast be properly supported during its application. The ill advised grasping of a heel or knee through layers of wet bandages will cause, when the cast has set, a painful projection in the interior of the cast. A leg should be held by the toes and a hand by the fingers. If it is necessary to produce a small amount of flexion at the knee joint, this should be done with great care not to make indentations in the cast. Luck,[240] who has written a most interesting paper on plaster of paris casts which all students should read, warns against the weakening effect on the cast of movement or molding after the "critical point" in the setting. He says: "Detection of the 'critical point' requires practice and varies with different brands of plaster, but in general it is that point when the plaster is of the consistency of thick cream and begins to lose its wet glistening character. When the appearance of the plaster has become dull and the cast is becoming firm, the 'critical point' is passed." A broad surface should be employed to produce flexion. When the proper thickness of the cast has been obtained, the ends of the stockinet may be turned back on the cast and made fast by a few additional turns of plaster of paris bandage. It is best to have the patient remain quiet for fifteen to thirty minutes, until the cast is thoroughly set,

before being moved. When the patient returns to his bed or home it will be well to have the cast exposed to the air for twenty-four hours to hasten drying.

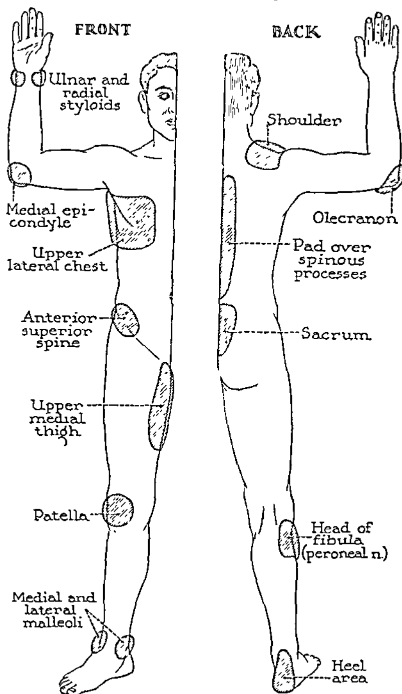


Fig. 553.—Areas which should be carefully protected by felt, rubber or cotton pads before being incorporated in a plaster cast. (Compere, E. L., and Banks, S. W.: Pictorial Handbook of Fracture Treatment, Chicago, Year Book Publishers, Inc., 1943.)

Various methods are employed in the removal of casts. The most useful is the large cast cutter. This is nothing more than a specially devised type of scissors with long handles to secure better leverage. When it is in use, the blades of the cast cutter should be outside of the stockinet so as to minimize the danger of pinching the skin. The cast cutter operating on the curved saw

principle is also useful. In the absence of a cast cutter, a sharp-pointed cast knife or cast saw will serve. The portion of the cast to be cut is moistened with water or hydrogen peroxide in order to soften it, and a V-shaped trench is cut in it by means of the cast knife. Acetic acid or a 50 per cent sodium citrate solution is useful in softening casts (vinegar will help).[239] Shelling and Cohen[241] advise the use of a 25 per cent solution of potassium citrate for softening casts. This solution combines with the calcium. It may conveniently be applied with the trough-shaped instrument devised by Barnes.[242] This trench is gradually deepened until the cast is cut through, the cast knife being held carefully at an oblique angle to the surface of the cast. This precaution is essential to minimize the danger of cutting the extremity beneath the cast. A very heavy cast will have to be cut on two sides so as to split it into halves for removal. The majority of casts, however, may simply be spread apart by the hands or by the specially designed cast divulsor.[243] Grossman[244] emphasizes the assistance in removal of plaster of paris casts by preliminary soaking for fifteen to twenty minutes in warm water.

The technic of the making of *molded plaster of paris splints* has been previously described. (See section on molded splints.)

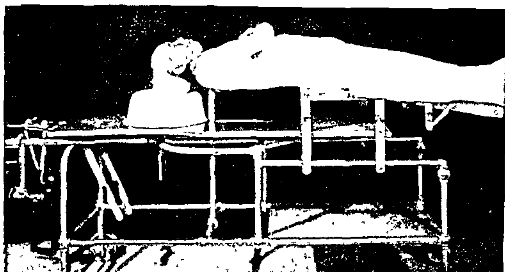
A circular body cast for encasing fractures of the vertebrae without neurologic symptoms is generally put on in the following manner: The patient is placed face downward upon the suspending hammock of an Abbott frame. Two layers of stockinet are placed about the patient's body, and the canvas hammock is passed between them. The hammock is adjusted so that the proper degree of lordosis is obtained. After the stockinet and sheet wadding have been applied in the usual manner, felt pads are placed over the spines of the scapulae, the spines of the vertebrae, the sacrum, and the crests of the ilia. The wet plaster bandage is then wound around the body, generally beginning over the hips and working upward. After the cast has thoroughly set, the end attachments of the hammock are unfastened, and the patient is lifted to a cart. The hammock then may be withdrawn from beneath the cast. The cast should then be cut out so as to give ample room for defecation, to permit the thighs to be flexed and to prevent cutting in under the arms.

Plaster hip spicas may be single or double, according to whether one or both hips are to be enclosed. The patient is placed upon a Hawley table, the shoulders resting upon the upper part of the table and the pelvis upon the pelvic support. An ample-sized felt pad is placed upon the vertical bar of the perineal support so as to protect the perineum when traction is applied. Traction is made upon the suspended extremity. For the application of traction, the device of Reich[245] is valuable. He describes the device as follows:

"A piece of strong flannel or muslin bandage 1 yard in length and 4 inches wide is employed Starting at a point approximately 16 inches from one end, the strip is slit longitudinally down the [illegible]

[illegible] where the slit begins is tied tightly together with a piece of 2-inch gauze bandage. By tying a single bow knot with another strip of gauze bandage approximately 1 yard long, the loop is adjusted snugly to the ankle joint. The traction strap is now applied to the beam of the table employed, and the gauze bandage ends extending from the bow knot are draped around the beam close to the traction strap, and plaster-of-paris bandage is applied, with the padding over the traction strap. Some talcum powder over the ankle assists the flannel or muslin to slip out more easily.

"When the plaster has sufficiently set, the traction strap is released from the beam, and the ends are slightly freed at their points of exit from the cast. Then taking the two ends of the gauze bandage in either hand and gently pulling, the single bow knot is easily



[illegible] L. C.: J. Bone & Joint Surg. 12: 434, 1930.)

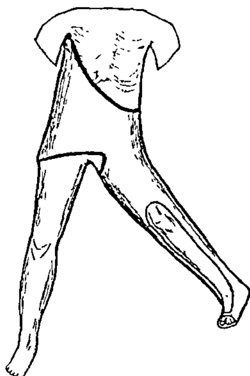


Fig. 555.—The modified Whitman spica. The freedom of the ribs on the abducted side, also the window permitting patellar exercise and massage of the muscles of the leg, may be noted. (Galland, W. I.: J. A. M. A. 96. 110, 1931.)

untied and that side of the traction strap which is split in two is cut off near its exit from the cast. Then pulling the other end of the strap firmly but cautiously, it is extracted on the opposite side with very little difficulty. The points of exit may be sealed if desired."

With the patient held so that there is the desired amount of abduction and inward rotation of the foot, the plaster cast is applied. Care must be taken to cut out the cast sufficiently from the region of the perineum to permit defecation and urination. Chu[246] has pointed out how the Hawley table may be employed in the application of a shoulder spica (Fig. 554). Galland[247] has described a convenient abduction spica (Fig. 555).

For tuberculosis of the spine body casts are constructed with the patient suspended by a neck halter.

Taylor,[248] who writes from Panama, says: "(1) Ordinary grades of plaster of paris are subject to rapid deterioration in tropical climates, which renders them unsuitable for exacting use. (2) High grade French plaster of paris, packed in small containers, is stable and should be given preference when possible. (3) Mixtures of Portland cement and starch have been used satisfactorily as substitutes for plaster of paris. The materials are cheap and readily available, and are not subject to deterioration. (4) The cement-starch cast compares quite favorably with casts made of the ordinary grades of plaster of paris and is superior to those made of deteriorated plaster."

Benatuil[249] prepared a mixture of 1,000 Gm. of desiccated alum and 500 cc. of water to be used instead of plaster of paris in making permanent dressing for fractures, dislocations and diseases of the joints. The substance transmits roentgen rays and solidifies twenty minutes after its application.[250]

Of the new cast material sold under the trade name "castex," Peterson[251] says: "It is 70 per cent lighter and four to five times stronger than plaster of paris." This author finds it resilient, permeable to *x*-rays and easy to apply.[252] The glass plastic cast described by Anderson[253] is waterproof and weighs one-fourth to one-sixth as much as a plaster cast.

Bandaging.—Bandages are employed to hold in place dressings and splints and to support joints and certain fractures. The requisites for a successful bandage are as follows: (1) it should efficiently hold the dressing or splint in place; (2) it should be comfortable; (3) it *should not come off*, and (4) it should have a neat appearance. Gauze bandages are most suitable for the majority of uses. Muslin bandages are used only when great strength is required, but they cannot be so neatly applied. Many experienced persons believe that the best results are obtained with the muslin bandages but that more skill is required to apply them. Woven bandages ("Ace," "Adaptic") are very useful for many purposes. A semi-elastic cotton gauze bandage has been described by Goldthwait and his associates.[254] The "Ace adhesive bandage" has been used in the treatment of varicose veins and ulcers and other conditions. All bandages may better be accommodated to the convexities and concavities of the surfaces which they are to cover by the occasional turning or reversing of the bandage. Many types of bandages have been elaborately described in textbooks on bandaging, but if the principles here mentioned are kept in mind, practically any portion of the body may be successfully bandaged.

A few special types of bandage deserve separate mention. The *head* bandage is applied by first making several turns around the head at the base of the skull, so that it is *firmly applied to both* the inion and the glabella (Fig. 556). A common error in head bandaging is not to have the bandage extend low enough so as to include the external occipital protuberance. Back and forth layers of bandages are then applied and held at the ends by assistants until the entire cranium is covered, when the circular bandage just described is repeated. All head bandages are properly reinforced by transverse or circular strips of adhesive plaster (Figs. 558, 559).

All *finger bandages* which are to be moistened should extend to and include

the wrist in order to prevent their falling off. The attachment of the finger bandage proper to the wrist portion should be made by turns of bandage which pass over the dorsum of the hand and not over the palm. The end of



Fig. 556.—First step in applying a head bandage The bandage is firmly wound over the occiput and forehead.

the finger is covered by bandage by making several back and forth turns, which are then held by subsequent circular turns (Fig. 560). An excellent method of preventing small dry finger bandages from coming off is that suggested by Wendel.[255] A small piece of adhesive plaster is so folded that one



Fig. 557.—Next step in applying a head bandage.

surface will adhere to the finger and the other to the inner side of the bandage (Fig. 561).

The *Velpeau bandage* is applied as follows: "Standing facing the patient, the operator holds the bandage in the hand opposite the injured side, and

with the other hand holds the free end against the chest of the well side. The bandage is carried across the injured side, crossing the middle of the arm, and

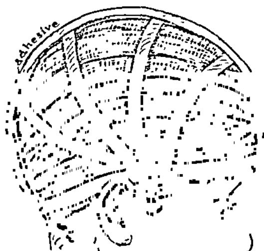


Fig. 558.—Final appearance of a head bandage.



Fig. 559.—Transverse recurrent bandage of the scalp. (After Whiting.)

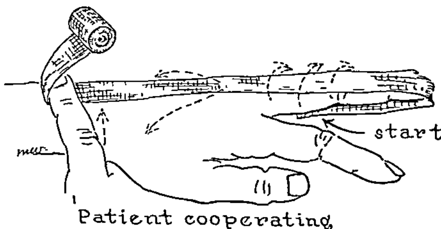


Fig. 560 —Finger bandage with extension to the wrist.

is then carried across the back to the starting point. This first turn about the chest and arm anchors the bandage. The next turn passes obliquely across

the chest to the injured shoulder, crossing the shoulder near its tip and passing down the back of the arm to the elbow, beneath the elbow, and up in front of the arm to the shoulder again, crossing the previous turn. From this point

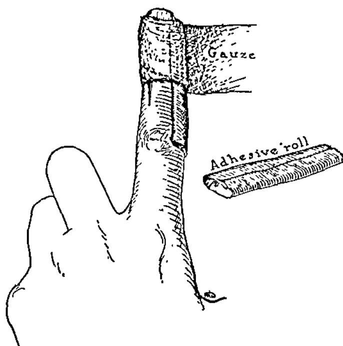


Fig. 561.—Method of preventing a small finger bandage from slipping off. (Courtesy of Dr. A. Wendel.)

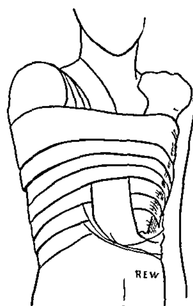


Fig. 562.—Velpeau bandage. (After Whiting)

the bandage is carried obliquely across the back of the chest on the uninjured side at a point level with the injured elbow. From this point a circular turn is made about the body, including the injured elbow, bringing the bandage again to the chest on the uninjured side. From here the bandage is carried to

the uninjured shoulder, down in back of the arm, up in *front of the arm* to the shoulder again, and then obliquely across the back to the starting point, following the previous *similar turn* and overlapping it about one-half. The

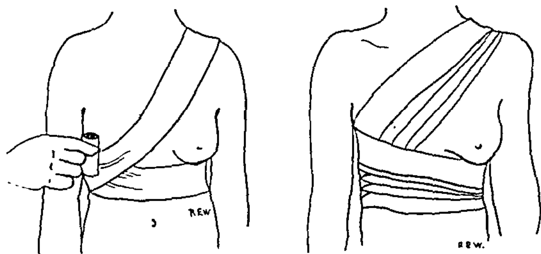


Fig. 563.—Suspensory of the breast. (After Whiting.)

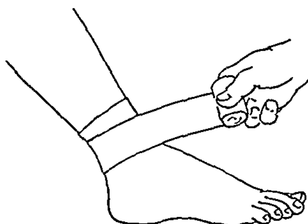


Fig. 564.—Circular method of fastening the initial turn of the bandage about the extremity. (After Whiting.)

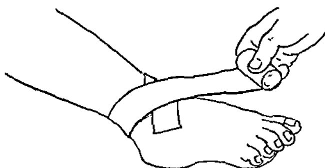


Fig. 565.—Oblique method of fastening the inital turn of the bandage about the extremity. (After Whiting.)

next turn is a circular turn slightly higher than the previous one, followed by a chest-shoulder-elbow-shoulder-chest turn." (Vaughan and Burnham;[256] see Fig. 562.)

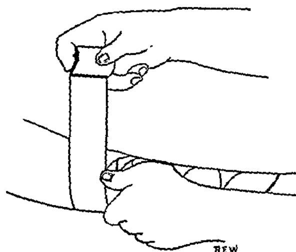


Fig. 566.—First step in making a reverse. (After Whiting.)

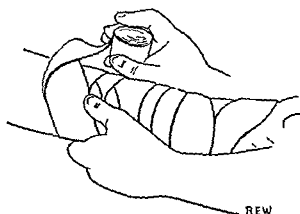


Fig. 567.—Second step in making a reverse. (After Whiting.)

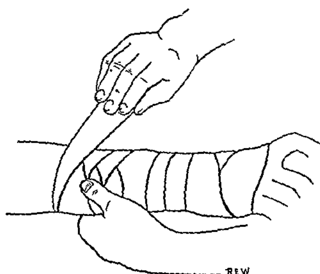


Fig. 568.—Third step in making a reverse. (After Whiting.)

Figure-of-8 Bandage to Support the Breast.—This bandage is started at the shoulder, is passed down under the breast of the opposite side, under that

axilla, over that shoulder, down in front of the chest under the opposite breast' under that axilla, over that shoulder and so on (Fig. 563).

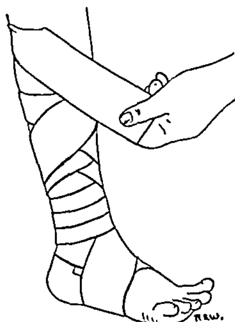


Fig. 569.—Modified spiral reverse of the leg. (After Whiting.)

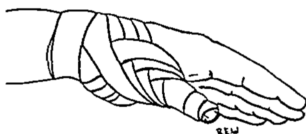


Fig. 570.—Spica of the thumb. (After Whiting.)

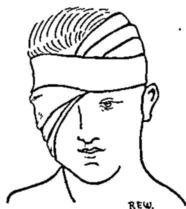


Fig. 571 —Monocle bandage of eye. (After Whiting.)

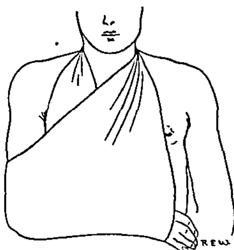


Fig. 572.—Sling. (After Whiting.)

Figure-of-8 Bandage to Support the Clavicle.—In this bandage, proper-sized felt pads are placed on the front of both axillas. The bandages are

crossed on the back so as to form a figure 8, the loops of which include the shoulders and hold them back.

Double-Roll Bandage.—Jonas[257] points out the advantages of using two rolls of bandage tied together when bandaging round or irregularly curved surfaces. One roll serves as the base to which the other roll finds secure attachment.

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CHAPTER XXIV

PREOPERATIVE AND POSTOPERATIVE CARE

PREOPERATIVE CARE

THE patient should be seen by the intern as soon as possible after admission to the hospital. Every patient is generally apprehensive, and friendly words of assurance, telling him that the necessary examinations will be started without delay, will often put him at ease. In emergency cases of all kinds, prompt, gentle and intelligent service is required.

History.—The intern's introduction to the patient generally will come with the taking of the history. A patient with a rather obscure complaint will generally welcome this procedure. Others, whose ailments are apparent, may be somewhat vexed to have to answer questions which they already have answered fully for the attending surgeon. Not only may the intern, by his history, make a valuable record of the case but also he may uncover valuable facts which have escaped the attending surgeon. To those patients who seem to offer objections to the taking of the history a good-natured explanation will generally insure cooperation. The detail with which the history is made will vary with the type of case and with the wishes of the attending surgeon. In obvious surgical afflictions, such as fracture, lacerated wounds and the like, a vary brief history will suffice. In cases of exophthalmic goiter, possible cholecystitis, gastric ulcer and the like, however, extremely careful and complete histories will be necessary. These will be carried out in a methodical manner.

[illegible]

"Medical cases vary greatly in their complexity. Some cases are so obscure that every possible piece of evidence [illegible]

[illegible] complete, or preclude special investigation in individual cases, is here offered:

"1. *Statistical Data.*

Name	Color
Address	Sex
Age	S. M. W. D.
Occupation	

"2. *Immediate Complaint.*—Under this head should be arranged the presenting symptoms as offered by [illegible]

"3. *The Pr*[illegible] of the disease from [illegible] the [illegible] res[illegible] chronologically as the symptoms have occurred up to the present time. Finally, the course of the disease should be noted.

246. Chu, L. C.: J. Bone & Joint Surg. 12: 434, 1930.
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251. Peterson, T. H.: Am. J. Surg. 41: 405, 1938.
252. See also Thorndike, A., Jr., and Garrey, W. E.: New England J. Med. 218: 205, 1938.
253. Anderson, R.: Northwest Med. 43: 365, 1944. Anderson, R., and Erickson, H. R.: Am. J. Surg. 69: 299, 1945.
254. Goldthwait, C. F.; Kettering, J. H., and Moore, M., Jr.: Surgery 18: 507, 1945.
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257. Jonas, A. D.: Am. J. Surg. 71: 365, 1946.

under no circumstances be examined in the absence of a nurse. Rectal examinations of virgins always should be made instead of vaginal examinations. In cases in which there is hemorrhage from the vagina, no vaginal examination is made.

The chief purpose of a routine physical examination is the accurate recording of the patient's physical condition and the possible revelation of pathologic conditions hitherto unsuspected. The physical examination will be systematic. During the conduct of the examination the intern should observe particular tact. He will continually be questioned by the patient as to the nature of the ailment and the significance of the findings. To these questions a noncommittal reply should be made.

The following is the outline guide for physical examination adopted by the Medical Division of the Northwestern University Médical School.

"*General Appearance.*—Race. Sex. Apparent age. Behavior. Posture. Gait. Nutrition. Height. Weight. Pulse. Temperature. Respiration. Blood pressure. Flushing. Pallor. Cyanosis. Icterus. Eruption. Pigmentation. Edema: Location, time of appearance.

"*Systemic Examination:*

"*Cranium and Scalp.*—Scars, hair, exostoses, cranium deformities.

"*Face.*—General appearance.

"*Eyes.*—Prominence of globe; exophthalmos; movements; coordination; conjunctiva; lids; ptosis, edema. Pupils: Size, shape, equality, reaction to light and accommodation; visual fields. Ophthalmoscopical examination.

"*Ears.*—Watch heard at ? cm. Condition of auricle; meatus and aural canal; discharge; tophi.

"*Nose.*—Deformities; obstruction; discharge.

"*Lips.*—Color; herpes; ulcerations; fissures.

"*Mouth.*—Breath; ulcerations; pigmentation. Teeth: Missing; cavities; apical infection; discoloration; dentistry. Gums: Character; bleeding; pyorrhea; lead line. Tongue: Coat; eruptions; direction of protrusion; tremor. Tonsils: Size, color, infection, exudate; anterior pillars. Pharynx: Color, catarrh; palate; reflexes; adenoids. Larynx: Character of voice.

"*Neck.*—Mobility; thyroid—character, bruit, lymph glands; tracheal tug.

"*Thorax.*—Inspection: Symmetry, size, and shape; expansion on both sides; depth and character of respiration; suprasternal notch; xiphocostal angle; supra- and infraclavicular fossae; Litten's phenomenon; Broadbent's sign; abnormal pulsations.

"*Lungs.*—Palpation: Vocal fremitus (compare two sides); pleural friction; succussion.

"Percussion: Resonance; dullness; flatness; outline Krönig's isthmus; border; apex; excursion of [illegible]

" [illegible]

" [illegible]

" [illegible]

"[illegible] Left cardiac border; apex beat; abnormal pulsations; thrills.

"*Percussion:* Outline and mark with skin pencil cardiac borders; measure (midsternal line to left and right borders); cardiac displacement.

"Auscultation: Tones—first and [illegible] area; note quality; redup[illegible]

[illegible] width.

[illegible] rate; rhythm; equality; character of vessel walls; brachial, temporal, femoral; capillary pulse. Auscultate femoral arteries; Traube's tones; Duroziez's murmur. Veins: Note any abnormalities.

"*Abdomen.*—Inspection; type—obese, scaphoid, ascitic, gas, enteroptosis; peristaltic waves.

"Enlargements: Veins, hernia.

"Palpation: Rigidity; tenderness, local or diffuse; tumors; friction.

"Liver: Size, dulness, excursion, notch, regularity of lobes, resistance, tenderness; tumors; scars; pulsations; friction; murmurs.

"Gallbladder: Palpability; tenderness.

"Spleen: Splenic dulness; excursion; notch; resistance; tenderness; regularity; friction

"Up to this point the information should be obtained from the patient by indirect questions; the patient should be allowed to tell his story in his own way without being influenced by direct questions, as, 'Have you a pain in your right side?' etc.

"Notes previously taken are now used in writing the history of the present complaint on a permanent history sheet.

"4. *Inventory by Symptoms.*—Direct questions may now be used in order that a complete inventory of the patient's condition may be taken under the headings given below. In this manner symptoms which may be forgotten or regarded as unimportant may be elicited and recorded.

"*General.*—Personality, nutrition, deformities, weakness, edema, dyspnea, fever, night sweats, jaundice, tremor, falling hair, skin eruptions. Weight: Loss or gain; over what period?

"*Head.*—Headache: Time of onset, duration, intensity, frequency, location. How modified by rest, sleep, or excitement, or drugs? Injuries.

"*Eyes.*—Failing vision. Glasses. Diplopia. Pain Photophobia. Scotomata.

"*Ears.*—Deafness: Unilateral or bilateral. Pain. Discharge. Tinnitus. Vertigo.

"*Nose.*—Obstruction. Nose colds. Discharge. Epistaxis.

"*Mouth.*—Glossitis. Gingivitis. Condition of the teeth.

"*Throat.*—Sore throat. Tonsillectomy. Hoarseness.

"*Cardiovascular.*—Chest pain· Location, character, referred, severity, how produced. Asthma. Palpitation. Tachycardia. Faintness. Vertigo. Dyspnea: Severity and character. Edema: Type.

"*Respiratory.*—Chest pain: Location, character, relation to respiration. Cough: Duration. Sputum. Character, amount, blood. Dyspnea: Type.

"*Gastro-Intestinal.*—Appetite: Normal, increased, decreased. If patient does not eat, is it because of distress? Abdominal distress or pain: Location, time of occurrence, periodicity, relation of food, effect of alkalies, relation to bowel movement. Differentiate between distress and pain. If patient has had attacks of distress or pain, describe a 'typical attack.' Nausea. Vomiting: Character of vomitus, hematemesis. Belching. Flatulence. Constipation: Cathartics, enemas. Diarrhea. Number of stools daily. Stool: Time, consistency, color, mucus, blood, undigested food. Hemorrhoids.

"*Genito-Urinary.*—Genital: Discharge. Sores: Location and character. Bubo. Urinary: Urine: Frequency, increase or decrease in amount; nocturia; incontinence. Character of urine; pyuria; hematuria. Pain Location, time of occurrences, relation to urination.

"*Neuromuscular.*—Temperament Emotional state; worry, fear. Motor disturbances: Muscular weakness, ataxia, convulsions, tremors, paralysis. Sensory disturbances: Fainting, paresthesia, anesthesia.

"5. *Past History.*—Record in chronological order all past illnesses, injuries, and operations. Record the date, duration, severity, complications, type of convalescence, and sequelae of each.

"Inquire specifically in regard to vaccination, scarlet fever, chorea, acute rheumatic fever, sore throat, tonsillectomy, association with cases of tuberculosis, pleurisy, dental care, venereal diseases.

"6. *Habits —Social and Working Conditions.*—Inquire regarding. Occupation; hygienic conditions, mental and physical strain. Sleep, exercise. Recreation. Drugs, alcohol, tobacco, coffee, tea.

"7. *Sexual History.*—*Male.* Marital. Duration. Health of wife Children. Miscarriages. *Female:* Menstrual cycle. Age of beginning, regularity, duration, amount, pain. Menopause.

If dead, age and cause of death. Inquiry should be made in particular regarding cancer, tuberculosis, diabetes, arthritis, insanity, and goiter. The history is concluded with a summary."

Physical Examination.—Great tact may be necessary in performing a physical examination upon a patient who has already been examined by the attending surgeon. In some cases the examination may be omitted at the expressed wish of the surgeon, but this is unusual. Female patients should

under no circumstances be examined in the absence of a nurse. Rectal examinations of virgins always should be made instead of vaginal examinations. In cases in which there is hemorrhage from the vagina, no vaginal examination is made.

The chief purpose of a routine physical examination is the accurate recording of the patient's physical condition and the possible revelation of pathologic conditions hitherto unsuspected. The physical examination will be systematic. During the conduct of the examination the intern should observe particular tact. He will continually be questioned by the patient as to the nature of the ailment and the significance of the findings. To these questions a noncommittal reply should be made.

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"*Systemic Examination:*

"*Cranium and Scalp.*—Scars, hair, exostoses, cranium deformities.

"*Face.*—General appearance.

"*Eyes.*—Prominence of globe; exophthalmos; movements; coordination; conjunctiva; lids; ptosis, edema. Pupils: Size, shape, equality, reaction to light and accommodation; visual fields. Ophthalmoscopical examination.

"*Ears.*—Watch heard at ? cm. Condition of auricle; meatus and aural canal; discharge; tophi.

"*Nose.*—Deformities; obstruction; discharge.

"*Lips.*—Color; herpes; ulcerations; fissures.

"*Mouth.*—Breath; ulcerations; pigmentation. Teeth: Missing; [illegible]
discoloration; den[illegible]
eruptions; directio[illegible]
pillars. Pharynx: [illegible]

"*Neck.*—Mobili[illegible]

"*Thorax.*—Inspection: Symmetry, size, and shape; expansion on both sides; depth and [illegible] lar [illegible]

[illegible] excursion of diaphragm (mark with skin pencil).

[illegible]

Palpation: Left cardiac border; apex beat; abnormal pulsations; thrills.

"Percussion: Outline and mark with skin pencil cardiac borders; measure (midsternal line to left and right borders); cardiac displacement.

"Auscultation: Tones, first and [illegible]
area; [illegible]
tory [illegible]

"*Aorta.* Palpation; percussion; auscultation, width.

"*Peripheral Vessels.*—Arteries, radial pulse rate; rhythm; equality; character of vessel walls; brachial, temporal, femoral; capillary pulse. Auscultate femoral arteries; Traube's tones; Duroziez's murmur. Veins: Note any abnormalities.

"*Abdomen.*—Inspection; type—obese, scaphoid, ascitic, gas, enteroptosis; peristaltic waves.

"Enlargements; Veins, hernia [illegible]

[illegible]

scar [illegible]

"Gallbladder: Palpability; tenderness.

"Spleen: Splenic dulness; excursion; notch; resistance; tenderness; regularity; friction

"*Rectal.*—Hemorrhoidal veins; fistulae; fissures; sphincters; stricture; tumor; discharge.
"Prostate: Tumors, tenderness. Seminal vesicles.
"*Genitalia.*—Male: Malformations; discharge; ulcers; scars. Testicles: Atrophy, inflammation, tumor, epididymitis. Hydrocele. Varicocele.
"Female: Ulcers; inflammation; discharge. Perineum. Vaginal: Hymen, cervix, fundus, adnexa, tumors, tenderness, fixation.
"*Inguinal Rings:*
"*Lymphatic Glands.*—Cervical, axillary, inguinal, epitrochlear.
"*Bones.*—Spine: Scoliosis, lordosis, rigidity, tenderness; other bones; exostoses; irregularities; tenderness.
"*Extremities*—Arms: Wasting, joint changes; club fingers; nails; tremor, involuntary movements, athetosis, choreiform.
"*Reflexes.*—Elbow; knee; ankle; Babinski; plantar.

Orders for the Patient.—The intern will be responsible for orders for the the medication and treatments given the patient. On the admission of the patient orders for diet, blood counts and urinalysis should be left immediately. The routine *preoperative* orders will be given in accordance with the custom of the individual attending surgeon. These should be given as soon as possible to facilitate the work of the nurses and orderlies. In the absence of knowledge of the customary orders the intern should ask the attending surgeon what he desires. The same applies to postoperative orders. When there is any question as to the indication for an order the intern should consult the attending surgeon. The orders should be written in ink and signed. The night before an operation an average dose of a barbiturate generally will give the patient a more comfortable night. The area of the operative incision is shaved, and in some instances it is washed with alcohol and covered with a sterile towel. *No laxative is administered,* but an enema is given on the morning of the operation. If avertin is to be used, an enema is given the night before and none the morning of the operation.

Special Considerations in Preoperative Care.—In recent years an increasing amount of thoughtful attention has been directed toward the proper preparation of the patient for a surgical operation. Intelligent and, if necessary, time-taking preparation will go a long way toward reducing the mortality and the morbidity of operations. Except in cases of massive, uncontrollable hemorrhage, nearly every operation can be delayed for at least a brief interval in which to prepare the patient.[1]

A. Shock.[2]—The picture of shock is well known. The patient is pale and sometimes cyanotic; the skin is cold and moist; the pulse is rapid and regular but "thready"; the respirations are usually rapid and shallow; the patient is thirsty and restless and shows anxiety changing to dulness. The essential physiology of shock is inadequate circulation of blood—"a diminution of the effective volume of circulating blood" (Blalock), oligemia. "This may be due to a decrease in the blood volume or *to an increase in the capacity of* the vascular bed (vasodilation) or to both." (Blalock) Freeman[3] defines shock as a condition "characterized by progressive loss of circulating blood volume due to generalized increase in capillary permeability." The latter may be due to a toxic substance produced at the site of an injury or to anoxia. *Gatch*[4] *speaks of shock as* circulatory failure in which the primary seat of

trouble is the capillary circulation, while Moon[5] speaks only of shock in cases of peripheral circulatory failure due to endothelial damage.

The *Journal of the American Medical Association*[6] says editorially: "Many clinicians still believe that a low or falling arterial pressure constitutes an early and obligatory feature of shock. Blalock,[7] Moon,[8] Harkins[9] and others have repeatedly pointed out that arterial pressure is a completely inadequate guide to the state of circulatory deficiency in incipient shock. Frequently the reactive vasoconstriction leads to an elevation of arterial pressure in the early stages of shock. A low blood pressure would follow later as a sign of advanced decompensation. This may account for the rare incidence of shock found by some investigators[10] in head injuries and some other conditions when blood pressure is used as the only criterion of shock. Moreover, lowering of the arterial pressure may be maintained for several hours, without serious impairment to the circulation, as recently shown by Phemister and his co-workers.[11] An opposite point of view regarding the value of blood pressure readings in shock has recently been expressed by Evans and his associates,[12] who concluded that, as compared with hemoconcentration and blood volume, the blood pressure level was the most valuable sign for early diagnosis of clinical traumatic shock in which hemoconcentration does not occur."[13]

Granting the general agreement that the most constant feature of all types of shock is a reduction in blood volume, Weil and Meakins[14] say: "In shock following hemorrhage, there is a reduction in blood volume due to loss of whole blood; in shock following burns, there is a reduction of blood volume due to loss of blood plasma; in shock following dehydration, there is a reduction of blood volume due to loss of water and crystalloids from the plasma. An increase in the capacity of the ...

volume may be present in certain cases, but in general one factor is predominant in any given case. The view that shock as it occurs in the human being is characterized by hemoconcentration due to a loss of plasma as a result of a generalized increase of capillary permeability, except perhaps as a terminal phenomenon, is no longer tenable. Hemoconcentration, moreover, is not a constant finding in all types of shock."

Shock has been classified as primary (neurogenic) or secondary (hematogenic).[15]

The causes of oligemic shock have been listed by Harkins[16] as follows: "1. Hemorrhage—to outside, into tissues, into body cavities. 2. Mechanical trauma—operative, accidental, trauma to intestines. 3. Thermal trauma—burns, freezing, peritoneal cooling. 4. Asphyxial trauma—mesenteric vascular occlusion, intestinal strangulation, tourniquet, heat stroke. 5. Actinic trauma—radiation burns, sunburn. 6. Chemical trauma—bile peritonitis, per-...

... coma, eclampsia. 10. Infections—cholera, pneumonia (especially influenzal and streptococcal) ...

... shock. (a) A downward trend in the systolic arterial blood pressure. The trend is more important than any arbitrary value. "To detect this gradual fall and be sure about it requires that the blood pressure be taken frequently, say every ten or every twenty minutes." (b) A reduced minute volume of flow of blood through the ...

... (Blalock and Price.)

Treatment of Shock.—(*a*) *Rest and Posture.*—The body should be horizontal or, better, the feet should be elevated and the head down.[18] (*b*) *Reassurance.*—Reassurance may go a long way to overcome vasoconstrictive

influences. (*c*) *Change of External Temperature.*—External heat is no longer advised in shock unless the rectal temperature is below 96 F. The patient with a cold, clammy skin may have a rectal temperature of 105 F., and the application of external heat can be distinctly harmful.[19] Excessive chilling should be prevented. Dry clothes should be substituted for wet ones as soon as possible. Wakim and Gatch[20] state that "an external temperature in the neighborhood of that of the mammalian body seems to be optimal for the survival of shocked animals." Allen[21] finds that "the survival of shocked dogs is lengthened by simple refrigeration of the injured legs, and still more by prolonged or intermittent tourniquet application with refrigeration."[22] (*d*) *Morphine.*—"Morphine by its depressant influence on metabolic processes and relief of pain diminishes the vasoconstrictive activities."[23] (*e*) *Hemostasis.*—Control of hemorrhage should be brought about with a tourniquet only when all other measures are ineffective. (*f*) *Immobilization of Fractured Bones.* (*g*) *Administration of Fluids.*—Fluids are given preferably in a vein or in the sternum. (See Sternal Infusion.) Oral and subcutaneous administration of fluids is usually impracticable or ineffective. The chief purpose of giving fluids is to replenish the blood volume.[25] Bywaters[24] points out that in crushing injuries myohemoglobin is released from injured muscle, and in the presence of acid urine tends to cause oliguria. He recommends in the shock due to crushing injuries that alkaline fluids be given by mouth or intravenously early and rapidly to prevent renal failure. Andrus[26] divides fluids for intravenous administration into six groups: (1) *Crystalloids* (normal saline solution, Ringer's solution, glucose solution) are now generally considered ineffective and in profound shock actually detrimental. They may in an emergency, by combatting dehydration, temporarily retard impending shock. (2) *Colloid solutions* (gum acacia, gelatin, pectin, etc.), although formerly popular, are in some cases now considered to be detrimental and in other cases of doubtful value.[27] (3) *Amino acid solutions* (casein digestate, "amigen" and "suprotein") are showing promise in correcting the acute protein deficiency (hypoproteinemia) in shock[28] but are far less desirable in true oligemia or hemoconcentration than whole blood or plasma.[29] (4) *Whole blood* (uncitrated or citrated—fresh or preserved) is by far the best solution when shock is due to hemorrhage. Whole blood which has been preserved longer than ten days is definitely less desirable for transfusion then fresh blood.[30] (5) *Plasma* (fresh, preserved or reconstituted) is easily preserved and when pooled eliminates the need of cross matching. Five hundred to 1500 cc. of plasma may be required in traumatic shock. Plasma is superior to blood in shock due to burns, where there is hemoconcentration and the hemoglobin value is elevated. However, in cases of shock due to hemorrhage, if whole blood is not available, plasma is the second choice. (See the section on Burns.) (6) *Serum* (fresh, preserved or reconstituted) is somewhat less desirable than plasma. Both plasma and serum are usually given after being reconstituted from the dried state by the addition of distilled water. Isotonic plasma or serum is generally preferable, although hypertonic plasma or serum has its advocates.[31] Of great value in the appraisal of shock is examination of the blood by the falling-drop method of Barbour and Hamilton,[32] which has been so greatly developed by Scudder.[33] The latter[34] has devised a "shock cart" and also a travelling case for carrying the laboratory apparatus necessary for making rapid determinations of specific

gravity of peripheral blood, hematocrit readings on venous blood, specific gravity of plasma and total plasma protein value.[35] Jenkins and his associates[36] have devised a simple guide to replacement therapy in shock due to loss of blood or loss of plasma. It is based on the hematocrit value (normal being taken to be 45 per cent) and the body weight (normal blood volume considered to be two twenty-fifths of the body weight). Their chart (Fig. 573) offers a simple means for evaluating the *minimum* requirement of blood or plasma, particularly in the early phases of shock. Harrison and Picken[37] say that the normal plasma volume and red blood cell volume are each about 5 per cent of the body weight and that the number of grams of protein per

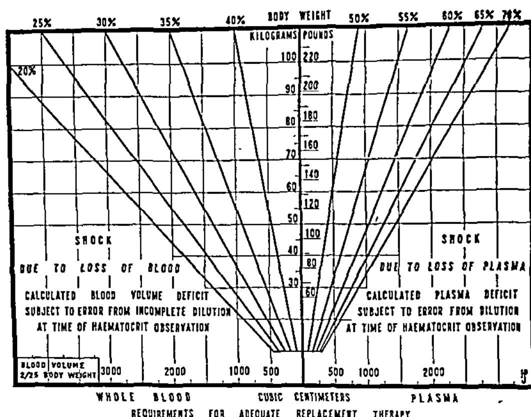


Fig. 573.—To determine the requirements for replacement of blood or plasma, follow the *diagonal line of the hematocrit reading to the point where it intersects the horizontal line* of the patient's body weight, in either kilograms or pounds; then follow the vertical line down to the calibration of the required amount of blood or plasma on the bottom line of the chart. (Jenkins, H. P.; Schafer, P. W., and Owens, F. M., Jr.: Arch. Surg. 47: 1, 1943.)

500 cc. of filtered plasma is 35; of citrated plasma, 23; of citrated whole blood, 15; of defibrinated whole blood, 18. These authors point out that severe hemorrhage (3 pints of plasma and 3 pints of red blood cells) "would necessitate the replacement of 119 Gm. of plasma protein as 3.4 pints of filtered serum, 5.1 pints of citrated plasma, 8 pints of citrated whole blood, 6.6 pints of defibrinated whole blood—which would be the maximum quantity to be used in severe hemorrhage. Most cases would require less."[38]

(*h*) *Oxygen.*—Administration of oxygen is helpful in combatting anoxia, which is responsible for many of the features of shock and in particular for local tissue damage (Andrus). Oxygen may be given by nasal catheter, or concentrations as high as 90 per cent may be obtained with the Boothby

mask.[39] (*i*) *Cortin* (Adrenocortical Hormone).—Andrus[26] says: "It would seem highly probable that the administration of adrenocortical hormone is a valuable adjunct to transfusions of plasma in making the latter more effective in the presence of increased capillary permeability due to anoxia or to the direct effects of toxins. It is possible that it may also be useful in preventing or lessening the degree of such increased permeability if administered early. Great reserve should be exercised in accepting the role of the hormone in the prevention of traumatic or surgical shock until considerably greater series of well controlled cases can be presented."[40] (*j*) *Vasoconstrictor Drugs.*—Of the vasoconstrictor drugs, ephedrine and veritol are the best,[41] but their value is uncertain. (*k*) *Stimulants.*—Of the various stimulants, caffeine is the best. (*l*) *Alkalis.*—Bywaters[42] points out that in *crush injuries*, even though the patient is adequately treated for shock with transfusions, renal failure develops later. He attributes this to blocking of the renal tubules with myohemoglobin, which like hemoglobin is less soluble in acid urine. To combat this phenomenon Bywaters gives sodium citrate and sodium bicarbonate by mouth or sixth-molar (M/6) sodium lactate (1000 to 2000 cc.) intravenously until the urine is definitely alkaline (a pH higher than 7.5). This method of alkalinization is also of great value in increasing the effectiveness as well as diminishing the renal irritation of the sulfonamides. (*m*) *Barbiturates.*—There is some evidence that barbiturates may have a "shock delaying" effect.[43] (*n*) *Local Treatment of Injury.*—The local treatment includes débridement and the use of pressure dressings, a tourniquet, sulfonamides, etc. (*o*) *Nerve Block.*—Phemister and Laestar[44] find no indication for efforts to prevent shock "by blockage of afferent nerve impulses through the use of local or spinal anesthesia."

B. Dehydration. (See also Shock.)—A dehydrated patient must be as adequately hydrated as possible before operation. A dry skin and dry tongue are familiar findings in a patient who has lost excessive quantities of fluids as a result of vomiting or has had an inadequate fluid intake. These findings are usual in cases of high intestinal obstruction. Despite the urgency of the need for operation, the outcome will be more favorable if time is taken to give the patient 1000 to 3000 cc. of fluid in the veins (usually 1000 cc. of 5 per cent dextrose in Ringer's solution plus the balance of 5 per cent dextrose in distilled water).[45]

C. Weight Loss.—Varco[46] says: "Many patients with gastrointestinal lesions remediable by some surgical procedure present nutritional problems. When a large amount of body weight has been lost by such an individual, the hazards of surgery are increased. Surgery in these patients can be performed [illegible] approximately the same mortality as in the standard-risk patient when [illegible]. An adequate dietary prepa- [illegible] when no obstructive element [illegible] arbohydrate, caloric, low fat diets." Varco gives detailed instructions for these diets.

D. Anemia.—Sudden loss of blood from a profuse hemorrhage has been considered in the section on shock. The patient with anemia due to longstanding small losses of blood, as in carcinoma of the right colon or duodenal ulcer, should be given appropriate iron preparations and repeated transfusions in preparation for operation.[47]

E. Prolonged Bleeding Time or Coagulation Time; Hypoprothrombinemia.—

Errors in coagulation of the blood are of particular interest to the surgeon.[48] Tests of bleeding time, coagulation time and prothrombin time should invariably be made in cases of jaundice, suspected hemophilia, purpura haemorrhagica, aplastic anemia and certain other conditions and in the case of newborn infants. While the prothrombin time by the method of Quick[49] or of Warner and his associates[50] is an accurate guide, the Ivy bleeding time test probably gives equally accurate information.[51]

Ivy Bleeding Time.—Ivy and his associates[52] say that Duke's bleeding time is, to a large extent, disappointing in jaundice. Ivy suggests applying the cuff of a sphygmomanometer around the arm, with a pressure of about 40 mm. of mercury, enough to cut off effectively the venous return. By increasing the pressure in the capillaries and arterioles in this manner, the factor of "capillary tonus" might be eliminated. This was done, with most gratifying results.

strated by the total area of the drop on the filter paper. After many trials the upper limit of normal for the venous pressure bleeding time was fixed at 240 seconds; it was rarely over 180 seconds. But when the method was tried on a number of cases of jaundice, it was found that often, when the Duke's bleeding time was normal, the venous pressure bleeding time was definitely prolonged. These cases with a prolonged venous pressure bleeding time were almost

vitamin deficiency.)

F. Decreased Bleeding Time or Coagulation Time.—If a patient is known to have a tendency to postoperative thrombosis, as indicated by the history or immediate findings, anticoagulant therapy may be indicated. (See the section on postoperative thrombosis.)

G. Vitamin Deficiency (*Avitaminosis*).—The existence of avitaminosis is at present, according to Starr,[53] determined chiefly from the clinical history. It may arise from an inadequate intake, inadequate absorption, increased requirements or increased secretion.[54]

Vitamin A probably has little if any direct bearing on surgical problems. In regard to *vitamin B* Sydenstricker[55] says: "Deficiency of thiamine (B_1) is typically characterized by the syndrome of beri-beri. Much more frequently anorexia, vague nerve and muscle pains, slight edema, and disturbances of gastrointestinal motility are evidences *of the disease*." Sudden death has been reported following the intravenous injection of thiamine hydrochloride.[56] *Riboflavin* deficiency does not play an evident part in [illegible]

"*Nicotinic acid* deficiency seems [illegible] gical conditions. This is not surpris[illegible] are the most common type of nut[illegible] subclinical pellagra are quite simil[illegible] fatigue, anorexia, and constipatic[illegible] described as burning or sourness o[illegible] stomach occur rather early. The more severe psychic and somatic evidences of *deficiency are* apt to be precipitated by [illegible]

[illegible]

In regard to *vitamin C*, Sydenstricker[55] says: "Inadequate intake of *ascorbic acid* is extremely common though *clinical scurvy* is quite rare. The symptoms of mild ascorbic acid deficiency cannot be differentiated from those of other vitamin deficiencies. Severe grades

of depletion are characterized by definite evidences of increased capillary fragility, petechiae and ecchymoses occur from minimal trauma or spontaneously. Oozing from the mucous membranes may occur and there may be subperiosteal or intra articular hemorrhages. Bleeding is not from any disturbance of coagulation but presumably from lack of coherence of the endothelial lining of the blood vessels. These effects of vitamin C deficiency are late and are slow to occur in the presence of an adequate supply of the other vitamins. There are simple tests available for the determination of the concentration of vitamin C in the blood and for the rate of urinary excretion as well as for capillary fragility."

Since Lanman and Ingalls[57] demonstrated that vitamin C deficiency leads to poor wound healing in children, considerable evidence has been brought forth to prove that this influence

chronic illness, such as peptic ulcer, gallbladder disease, obstructing gastro-intestinal lesions, and the like, confine their diet to soft well-cooked foods which are almost totally lacking in vitamin C. Their diets are especially lacking in orange juice, fresh fruits, and raw vegetables, the chief sources of vitamin C."[60]

Probably the most important of the vitamins to the surgeon is *vitamin K*, the antihemorrhagic vitamin. Sydenstricker[55] says: "Deficiency of viatmin K is to be suspected in all patients with a history of seriously deficient diet, in all with intestinal hypermotility and in every instance of biliary or hepatic disease. The dietary sources of the vitamin are not abundant, absorption seems to depend on ample mixture with bile and the manufacture of prothrombin by the liver seems to depend on its functional integrity. Fortunately there are simple and rapid methods for the determination of the relative concentration of prothrombin in the blood which for clinical purposes can be interpreted in terms of vitamin K deficiency."

The percentage of normal clotting activity is the normal plasma prothrombin time in seconds divided by the patient's plasma prothrombin time in seconds.[61] Bleeding may occur at any level below 70 per cent; however, it is relatively uncommon until the level has approached 50 per cent.[62] Vitamin K is also of especial interest to surgeons because of the diagnostic value of the prothrombin response to vitamin K therapy in differentiating between intrahepatic and obstructive jaundice. Allen[63] says:

"The differential diagnosis between intrahepatic and obstructive jaundice can be made with a high degree of accuracy when one observes the plasma prothrombin response to a course of vitamin K therapy. In obstructive jaundice, uncomplicated by acute cholangitis, and when the jaundice is of less than six or eight weeks' duration, there is a very rapid response to the oral or intravenous administration of an adequate amount of vitamin K. Moreover, most patients with uncomplicated obstructive jaundice of from two to six months' duration will demonstrate a prothrombin response to vitamin K therapy which will enable one to differentiate clearly between obstructive and intrahepatic jaundice On the other hand, in patients with jaundice of intrahepatic origin, such as that resulting from toxic hepatitis or cirrhosis, the plasma prothrombin response is either slow or there is no change at all. If, at the end of twenty-four hours of adequate vitamin K therapy, little or no prothrombin response has occurred, the test is indicative of advanced hepatic disease and suggests that the jaundice is intrahepatic rather than obstructive. However, a rapid prothrombin response, with the prothrombin value returning to normal or nearly so after twenty-four hours of vitamin K therapy, signifies an obstructive type of jaundice. The

Sydenstricker[55] says:

"Most of the recent literature on vitamin therapy records experimental observations of the effect of single vitamins on presumably specific manifestations of deficiency. The therapeutic aim in the management of surgical patients is altogether different, we attempt to pre-

vent the development of any grade of nutritional disturbance or to cure any which may be present as rapidly as possible. These objectives are best accomplished by the use of a high vitamin diet and the administration of large doses of mixtures of synthetic vitamins supplemented when possible with small amounts of yeast or of liver extract. Patients fed through indwelling tubes can be given high vitamin liquid diet. Large daily doses of the water soluble vitamins should always be fractioned to avoid the loss in urinary excretion which occurs when single large doses are taken. Whenever there is reason to suspect that patients are in a state of nutritional inadequacy and certainly when there are any positive clinical findings of, or laboratory tests for, avitaminosis preoperative saturation should be attempted. Under ordinary circumstances this can be accomplished by oral administration of suitable preparations for four or five days. When nausea, vomiting, dysphagia or severe diarrhea is present intravenous or intramuscular injection must be used. If it is necessary to maintain patients on glucose solutions given by venoclysis the water soluble vitamins may be added to the solutions." No arbitrary dosage can be prescribed for preoperative vitamin administration. In addition to special diets vitamins may be given in concentrated form. Vitamin B_1 is given as thiamine 20 to 100 mg. daily. Nicotinic acid (500 mg. orally; 1.5 mg. per kilogram of body weight intravenously) and nicotinamide are suitable in cases of nicotinic acid deficiency. Riboflavin (vitamin G; 5 mg. daily) and pantothenic acid are also available commercially. Vitamin C may be given as cevitamic (ascorbic) acid. Lund and Crandon[58] advise giving 1 to 4 Gm. of cevitamic acid daily in the preoperative treatment of vitamin C deficiency (500 to 1000 mg. may be given intravenously).[65]

Vitamin K in its natural form is fat soluble and is administered orally accompanied with bile salts. Numerous synthetic forms of vitamin K ...

and operation is permissible. Vitamin K is also given postoperatively to jaundiced patients who required it before operation.[67]

H. Weight.—Obesity adds to the difficulty and risk of a surgical operation and should be corrected preoperatively if possible. Malnutrition and underweight should be treated by means of a high caloric, high protein and high vitamin diet.

I. Diabetes.—The diabetic patient requires expert management of his preoperative preparation. McKittrick and Root[68] say:

"A diabetic patient should ...

who underwent operations. There were 28 unexpected deaths in the series, or a mortality of 6.3 per cent. The unexpected mortality in the various forms of heart disease was as follows: valvular heart disease ...
... cent; auricular fibrillation,
3 p...
... 44.5 per cent; paroxysmal
tac...
... The risk was found to be

pectoris, conge...
valvular heart ...
the anesthetic ... risk." Brumm and Willius[72] studied 257 patients with severe coronary disease undergoing imperative surgical operations. "The average age of the patients was 60.3 years. The anginal syndrome ...

... surgical intervention is necess...
a false optimism into the c...
ment is not of casual origi...
study and judicious selecti...

* Allen has given 200 mg. of synkayvite in one dose without toxic effects or abnormal shortening of the coagulation time.

technic and judgment. Operation must be confined to those cases presenting unmistakable indications and the procedure limited to the primary condition. Surgical procedures that are not urgent have no place in the cases under discussion." When organic changes have taken place in the cardiovascular system, it is important to avoid any marked fall in blood pressure during an operation.[73]

K. Hypoproteinemia.—(See Postoperative Care: Food Needs.)

Special Types of Surgery.—*Thyroid Surgery.*—Rest in bed and mental relaxation are indicated, with a 3000 to 5000 calorie, high carbohydrate, high vitamin diet. "The patient should have as much additional food as he will take."[74] From 2000 to 3000 cc. of fluids is given daily. Lugol's solution (compound solution of iodine) is given in a dose of 10 minims three times daily for ten to fourteen days and in severe cases for several weeks.[75]

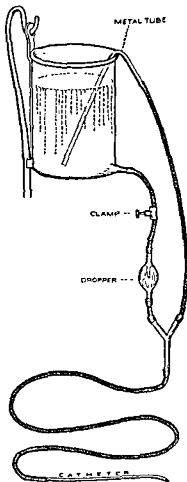


Fig. 574.—Apparatus for proctoclysis. (Kanavel, A. B., and Koch, S. L. Bull. Am. Coll. Surgeons 11: 14, 1927.)

Gastric and Duodenal Surgery.—Gastric retention is treated by means of bi-daily gastric lavage except when less than 500 cc. is obtained, when lavage once daily will suffice.[76] Vitamin deficiency must be corrected. Gray and Chauncey advise giving 10 mg. of thiamin [illegible]

value is abnormally low.[78]

Colon Surgery.—Proper preparation of the patient has greatly reduced the mortality rate of surgical operations on the colon in the absence of acute obstruction. The patient is placed

on a residue-free, high caloric, high vitamin diet three days before operation. A saline purgative (Fleet's phospho-soda, 6 drams) is given morning and afternoon of the first day and the afternoon of the second day. Paregoric administration is started the afternoon of the second day. Repeated cleansing (tap water) enemas are given the first and second days. Transfusions are given if indicated. Operation is scheduled for the third day. During the week preceding the operation succinylsulfathiazole (sulfasuxidine) is given in a dose of 0.25 Gm. per kilogram of body weight daily divided into six equal doses at four-hour intervals.[79] Intraperitoneal vaccination with killed streptococci and colon organisms is used at the Mayo Clinic.[80] When a colostomy is present, irrigations are carried out both through the colostomy and through the rectum.

Surgery of the Biliary Tract.—The preoperative diet should be a high protein, high carbohydrate and no fat diet (carbohydrate, 74 per cent; protein, 20 per cent; fat, not more than 6 per cent).[81] The Ivy bleeding time and prothrombin time should be checked and vitamin

tained.[83] McCall and Reinhold[84] say: "In carcinoma of the head of the pancreas, the serum lipase is usually increased and the serum amylase normal."

Thoracic Surgery.—For the important details of the preoperative preparation of patients undergoing thoracic operations, the articles by Alexander[85] and Harrington and his colleagues[86] are valuable.

Anorectal Surgery.—Cathartics are not usually indicated. The rectum is cleansed with several tap water, saline or soapsuds enemas before operation.[87]

Special Fields of Surgery.—For data on the preoperative care in urologic surgery consult Huggins and Vermeuler;[88] in cardiac surgery, Beck;[89] in gynecologic surgery, Gardner;[90] in neurosurgery, Pilcher;[91] in plastic surgery, Brown, Byars and McDowell.[92]

Preanesthetic and Preoperative Medication.—A barbiturate given the night before an operation is helpful. For this purpose pentobarbital sodium (nembutal), $1\frac{1}{2}$ grains, or seconal, $1\frac{1}{2}$ grains, will be useful. Morphine, pantopon or dilaudid, in proper dosage, combined with scopolamine or atropine is the usual preoperative medication. Avertin combined with atropine is useful in thyrotoxicosis. The student of preoperative medication will do well to consult the articles by Mousel and Lundy,[93] Robbins,[94] Sellman[95] and Gwathmey.[96]

POSTOPERATIVE CARE

Thoughtful attention during the postoperative period decreases the operative mortality and morbidity and accelerates the rate of recovery.[97] The principal considerations in postoperative care are (1) rest and relief of pain, (2) water requirements, (3) electrolyte needs, (4) blood loss factors, (5) food (caloric and nitrogen requirements), (6) vitamins, (7) oxygen needs and (8) management of postoperative complications.

Rest and Relief of Pain.—Morphine offers the most important and reliable means of alleviating pain. In those cases in which it produces nausea or in which there is sensitivity to it, pantopon, demerol, dilaudid or codein may be used. Batterman[98] recommends 75 to 100 mg. of demerol every three to four hours and says that its use does not alter the cough reflex.[99] These drugs are usually administered by hypodermic in dosage appropriate to the patient's age and weight. For oral medication a capsule containing 5 grains of aspirin and $\frac{1}{2}$ grain of codein is useful for moderate pain. Allen and his associates[100] have found that procaine administered intravenously has value in the relief of pain. One gram of procaine hydrochloride is placed in 500 to 1,000 cc. of saline solution and given intravenously over one to one and one-half hours. They say that danger to the patient is practically eliminated by keeping doses within the limits fixed by onset of dizziness. Patients who show the rare idio-

syncrasy to procaine are excluded by means of skin tests. Rapid and flexible control gives the intravenous method of administration a margin of safety over other methods. Infusion can be begun slowly, increased cautiously and halted immediately at the first sign of danger. Circulating procaine is destroyed within ten minutes.[101] For restlessness without marked pain, triple bromides and the various barbiturates, *e. g.*, phenobarbital (luminal), nembutal and seconal, should be employed. Sodium luminal may be given hypodermically. Some patients become somewhat disoriented or depressed by barbiturates. Seconal may be given by rectum, using two of the 1½ grain capsules, but usually is given orally, a pinhole being made in each end of each capsule. Ethyl alcohol intravenously is recommended as a postoperative sedative by Behan;[102] 50 cc. of 95 per cent ethyl alcohol is added to 1,000 cc. of 5 per cent dextrose in saline solution.* Behan says: "The rate of flow is regulated so as not to exceed more than 60 drops per minute. Intravenous injection of alcohol, if given too rapidly, may be painful and in a few patients has caused a slight sensation of syncope."[103]

Water Balance.—Of recent years numerous careful studies have demonstrated the vital importance of the maintenance of a proper postoperative water balance. The common error of previous years of administering too little water and producing dehydration was often supplanted by the error of "pushing fluids" and bringing about water intoxication.[104] Severely dehydrated patients may exhibit shock and die because of the lack of enough available water to supply the tissue cells with the requisite amount of fluid. Too much fluid, however, is particularly hazardous to older patients with an impaired cardiac reserve.[105] The danger of producing *water intoxication* is emphasized by Helwig and his associates,[106] who report an apparently fatal case. The "patient, following a simple cholecystectomy, absorbed 9 liters of tap water by proctoclysis within a period of thirty hours after operation and died in convulsions." Moreover the rate of administration and the presence or absence of cardiac impairment are of importance.

Murphy and Correll[107] say: "There are no tests of cardiovascular integrity so far known which will enable the clinician to determine beforehand if the cardiovascular system will [illegible]

possible administered very slowly. . . . Isotonic solutions in volumes up to 3000 cc. daily in 1000 cc. doses at rates of injection from 20 to 50 cc. per minute may be given without demonstrable cardiovascular changes in non-cardiac patients and cardiacs in Grades I or II compensation. In cardiac patients of Grades III or IV compensation, isotonic solutions in 1000 cc. volumes are definitely dangerous at rates of injection between 20 to 50 cc. per minute."[108] In a study of convalescent patients with cardiovascular disease, Sharpey-Schafer and Wallace[109] found that when the rate of injection was between 50 and 150 cc. a minute, the venous pressure began to rise after 1000 cc. of saline solution or serum had been given and reached a maximum toward the end of the injection. If the rate of injection was very rapid, as little as 500 cc. raised the venous pressure once the injection had been stopped.

It is now felt important to give as nearly as possible the *correct amount* of fluid and the *correct amount* of sodium chloride and other electrolytes. The basis of the correct administration of fluids and electrolytes to the patient after operation depends upon careful clinical and laboratory studies. The

* Five or ten per cent solutions of alcohol in 5 per cent dextrose in saline solution are available commercially, being prepared by Baxter Company.

very ill patient, who has vomited persistently before admission to the hospital will present the dry skin, dry tongue and thirst of the obviously dehydrated patient. Fluids will be administered to him at once intravenously or subcutaneously. After operation mere clinical appraisal may not be sufficient. Computing the twenty-four hour output of urine is a simple method of judging the patient's fluid requirements.

Coller[110] says: "From direct determinations on surgical patients it was concluded that the insensible loss could usually be covered by 1000 cc. in small inactive individuals and by 1500 cc. in the larger or more active. The water necessary to excrete the average amount of waste formed in the body daily (35 Gm.) amounts to about 500 cc. of water with the normal kidney concentrating near capacity (specific gravity, 1.030). The insufficient kidney requires more water to excrete 35 Gm. of waste, therefore, to have an adequate margin of safety requires that 1000 cc. be considered the minimum urine excretion in the surgical patient. The water lost normally in the stool is small, 100 cc. daily; that lost by sweating varies with the season, the temperature of the operating room, the extent of draping, and the type of covering of the individual before full reaction from the anesthesia has occurred. During the hot, humid weather of a Michigan summer, without air conditioning either in the ward or operating room, as much as 4000 cc. of sweat was lost in a single twenty-four-hour period by a patient quietly lying in bed. It was concluded, therefore, that an uncomplicated surgical case, not perspiring, requires from 2000 to 2500 cc. of water daily. Due allowance must be made from the increased requirements incident to fever, hyperthyroidism, and sweating. In general, under these conditions 3000 to 3500 cc. are required."

In addition to this, the abnormal losses of water, such as occur in vomitus, blood, drainage from intestinal and biliary fistulas, diarrhea, exudation from raw surfaces and even sputum must be considered.[111] Roughly then the amount of fluid to be administered to the sick surgical patient is the sum of (*a*) the insensible loss (1,000 to 1,500 cc.), (*b*) abnormal losses (variable) and (*c*) the amount of urine desired (750 cc. to 1,500 cc.). Usually this amounts to 3,000 to 3,500 cc. for the average adult. If the patient is dehydrated before operation this deficiency must be made good. Maddock and Coller say that "when the signs of serious dehydration are present in a patient, body fluids of an amount equal to at least 6 per cent of the patient's body weight have been lost. The figures . . . [in the accompanying table] show what this amounts to for individuals of various weights."

Amounts Equaling 6 per cent of Various Body Weights

Body Weight	*6 Per Cent*
10 Kg., or 22 lbs.	600 cc.
20 Kg., or 44 lbs.	1200 cc.
60 Kg., or 132 lbs.	3600 cc.
80 Kg., or 176 lbs.	4800 cc.

In addition to the clinical appearance and the intake and output studies, information as to the state of water balance may be obtained by laboratory methods. Scudder and his associates[112] use tests for the specific gravity of the peripheral blood, the hematocrit value, the specific gravity of the plasma and the total protein content. They state that these tests can be determined "within 15 minutes and afford accurate information about the state of the peripheral and venous circulating systems. They furnish data concerning the state of hydration. In cases of injury, changes of the specific gravity of capillary blood herald the approach of shock. One is thus forewarned and can institute therapy at a time when such corrective measures are most effective. These tests can differentiate shock due to internal blood loss from typical dehydra-

tion or traumatic shock before changes in blood pressure and before the appearance of the classic symptoms of shock." Gray and Chauncey[113] report a case in which it was necessary to administer 45,550 cc. of fluid parenterally in five days in order to maintain a positive fluid balance.[114] (See section on protein needs.)

Arnott and Young[115] studied the postoperative administration of fluids to children, and they have provided a table which shows the daily fluid requirements of children who are of average weight and height and from six months to seven years old. Condensed, it is as follows: 750 cc. at one year; 1,000 cc. at three years; 1,500 cc. at eight years; 2,000 cc. at twelve years; (average adult: 3,000 cc.).

Electrolyte Requirements.—The requirements for electrolytes (particularly sodium chloride) of the postoperative patient should receive closest attention.

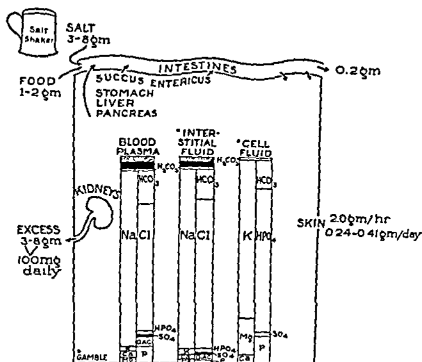


Fig. 575.—A diagrammatic presentation of sodium chloride metabolism. (Coller, F. A., and Maddock, W. G.: Surg., Gynec. & Obst. 70: 340, 1940.)

Coller[116] says that 5 Gm. of salt is adequate for the daily normal need and 10 Gm. in the hot and humid days of summer. Maddock[117] says that the patient who is not vomiting and does not have diarrhea or a fistula requires no salt.

Coller and Maddock[118] say: "The importance of sodium chloride to the body is well

stances in solution at the normal level. Dehydration thus follows sodium depletion more than chloride loss.

"Figure 575 also shows diagrammatically the normal metabolism of sodium chloride. From the total intake of 3 to 10 grams daily the largest portion comes from the vigorous use of the salt shaker as taste demands; the natural content of sodium chloride in the food is not much more than 1 to 2 grams per day. Along with this oral intake of salt the upper part of the gastro-intestinal tract receives through saliva, gastric juice, succus entericus, bile, and pancreatic juice about 8 to 10 liters of salt containing fluids daily. This is another remarkable example of body economy, namely, similar to the conservation of water practically all of the salt is later absorbed; the sodium chloride loss in the stool is reported at about 0.2 grams per day. The loss of salt from the skin is variable. With insensible perspiration Freyberg and Grant found values from 0.25 to 0.41 gram per day, which are negligible. With active sweating more salt is lost; upper limits under extremes of work, heat, and humidity are reported as high as 2.0 grams per hour. The kidneys excrete the excess sodium chloride remaining after the stool and skin losses have been deducted from the oral intake. In this way the normal sodium chloride balance is maintained."

Darrow[121] says: "Changes in the electrolyte pattern (or acid-base equilibrium) of the serum are frequent accompaniments of loss of extracellular water and electrolyte. If the loss of sodium is greater than the loss of chloride, relatively less than the normal amount of sodium is available to form bicarbonate. This condition results in acidosis. In alkalosis more than the normal concentration of bicarbonate is found in serum as a result of the relatively greater loss of chloride than sodium. Through the study of the composition of gastric juice, pancreatic juice, bile, diarrheal stools, urine and sweat, the various types of loss of extracellular electrolyte can be characterized as to their effect on acid-base equilibrium. In this sense most cases of acidosis and alkalosis may be regarded as special manifestations of deficit of extracellular electrolyte."

Coller and Maddock[118] add: "Chloride loss is shown by plasma chloride determinations; the normal value as expressed in the commonly accepted terms of sodium chloride is 560 to 630 milligrams per 100 cubic centimeters. For our calculations the lower limit of 560 milligrams per 100 cubic centimeters is used. Sodium loss or total base loss is impractical to determine directly because the chemical procedure is too time consuming. As a substitute a fair indication of total base concentration is obtained from a measurement of the plasma carbon dioxide ... er, which shows the amount of base in excess of ... the amount of sodium in excess of chloride *ions*. ... base and the normal value of the carbon dioxide combining power is 55 to 65 ... more ba ... volumes ... with the ... is lowered ... volumes per cent, and a condition of inorganic *acidosis is present*. It is important to remember that the plasma carbon dioxide combining power is a measurement of the base concentration relative to the acid concentration at *the time of the test*. A normal or even an increased plasma carbon dioxide combining power, obtained when plasma chlorides are materially lowered, indicates that some sodium has also been lost. An important practical point which will be stressed later *is that fluid lost* by vomiting or by removal through suction from the upper part of the gastro-... with it a loss of chlorides greater ... lation, then, of the proper amour ... loss for practical purposes provides for the sodium *loss* as well.

"In figure 576 a schematic presentation is given of the fluid from various portions of the gastro-intestinal tract and its acid or base predominance."

From the foregoing it may be seen that in pyloric obstruction there is an alkalosis with lowered plasma chloride content and a relatively increased carbon dioxide combining ... of the blood ...

... electrolytes needed, and (2) dextrose solution which provides

an excess of readily available water for kidney . . .

sodium chloride of vomitus (3.3 Gm.). ga

The management of the sodium chloride balance is chiefly clinical but blood chloride determinations are of supplementary value. Too much salt will cause water retention (edema) and increased thirst. Too little salt (following loss of salt by vomiting, fistulas, diarrhea, etc.) will cause lassitude, weakness, nausea, dehydration and even coma.

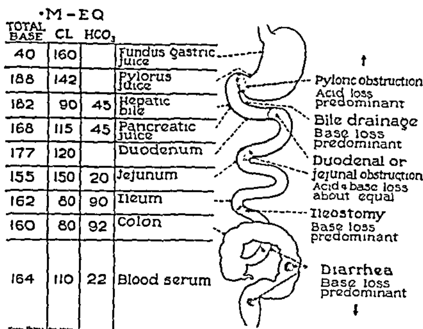


Fig. 576.—A schematic presentation of the fluid from various portions of the gastrointestinal tract and its acid or base predominance. (Coller, F. A., and Maddock, W. G.: Surg., Gynec. & Obst. 70: 340, 1940.)

In 1938 Coller et al.[122] proposed the clinical rule that for each 100 mg. per cent that the whole blood chlorides need to be raised to reach the normal (450 mg. NaCl per 100 cc.) the patient should be given 0.6 Gm. of sodium chloride per kilogram or 0.25 Gm. per pound of body weight. *Coller et al.*[123] *have now retracted this rule.* They say: "It is generally true that the body of a normal person is capable of handling relatively large amounts of isotonic saline solutions without showing signs that would indicate that a significant derangement in the regulation of body functions had occurred. However, there are many individuals who are incapable of tolerating relatively small excesses of salt solution, *during the immediate postoperative period.*" They describe three clinical types of "salt intolerance" and add: "Because of the relatively high incidence of 'salt intolerance' following a general anesthesia, it is felt that *no* isotonic saline solution or Ringer's solution should be given during the day of operation and during the subsequent first two postoperative days. The fluid requirement of the patient is met with glucose solution . . . It

is recommended that the correction of uncompensated extracellular fluid deficiency states be made upon the basis of the physiologic response to test doses of the appropriate salt solution rather than upon the basis of the plasma chloride, the CO_2 combining power, the N.P.N., the plasma protein, or the hemoglobin levels."

In later studies Coller et al.[124] find: "1. The injection of 'isotonic sodium chloride' solutions was attended by an average retention of 53 per cent of the sodium, 46 per cent of the chloride, and 19 per cent of the water 30 hours after operation. Such retentions of salt indicate a withdrawal of approximately two liters of fluid from the intracellular compartment in order to maintain isotonicity. 2. The infusion of hypotonic solutions resulted in the average retention of 27 per cent of the sodium, 32 per cent of the chloride, and 39 per cent of the water during the same postoperative period. Extra water is thereby provided for excretory function of the skin and lungs, and the intracellular compartment is not involved . . .4. *If intravenous infusion is indicated in the postoperative care of the surgical patient, hypotonic solutions, 0.45 per cent NaCl, or better 0.38 per cent NaCl plus 0.11 per cent $NaHCO_3$, should replace the 'isotonic' solutions commonly in use.*"

Coller and Maddock[118] say: "Parenteral therapy tides over an emergency; the sooner the patient is restored to food and drink by mouth the greater his chance of recovery."[125] Experiments by McDougal[126] indicate that "the administration of saline solutions for five postoperative days causes a delay in the healing of the laparotomy wound."

Winslow[127] says: "The routine use of 5 per cent dextrose in distilled water for patients who require water and some carbohydrate parenterally, either in preparation for or following an operation, is recommended for several reasons. It is isotonic with blood. Its dextrose content is sufficient to prevent ketosis and to provide ideal fuel for energy. It protects the liver and avoids the edema which may result from the promiscuous use of physiologic solution of sodium chloride. No serious complications, such as dehydration, diuresis, unusual loss or retention of fluids, which might be ascribed to the dextrose solution, have been noted when three liters are administered daily at rates of 300 to 500 cc. per hour. This is an inadequate daily caloric intake, but this is not an important objection in patients with fair general nutrition, or in those who will be taking food by mouth in a few days. It has been shown that about 98 per cent of the dextrose is utilized when administered at the rate of 300 to 500 cc. per hour, averaging 0.35 Gm. of dextrose per kg. of body weight per hour.

"Ten per cent dextrose in distilled water is hypertonic with blood, is mildly diuretic, and can be given at the same rates of administration as 5 per cent dextrose without harmful effects, supplying the patient with 93 per cent more carbohydrate than an equal volume of 5 per cent dextrose solution. In this study 95 per cent of the administered dextrose (10 per cent solution) was utilized, making this solution our choice in the presence of liver damage, thyroid crisis, inanition, and cachexia. Although no measurable damage was noted at a rate of 500 cc. per hour, administration of the 10 per cent solution at 200 to 300 cc. hourly is preferred to increase its utilization."

Hartmann[128] developed a combined solution of physiological buffer salts effective against dehydrations with alkalosis or acidosis.

Each 10 cc. of this solution contains:		
Lactic acid 85% (as sodium lactate)	0.6	cc.
Sodium chloride	1.5	Gm.
Potassium chloride	0.1	Gm.
Calcium chloride	0 05	Gm.
Distilled water q. s. ad.	10.0	cc.

It works on the following principle: It restores (1) water to the dehydrated blood and tissue fluids because of its hypotonicity; (2) chloride; (3) sodium, potassium, and calcium in the proper proportions; and (4) sodium bicarbonate (independently of renal activity); as

well as exerting an antiketogenic effect. In short, it contains all the important substances lost in the body in the development of dehydration with acidosis or alkalosis. It is of such composition, however, that the body, even in the presence of severely damaged kidneys, can select from it what it needs for retention and yet excrete what it may not require.[129]*

To combat acidosis Bywaters[130] gives sodium citrate or sodium bicarbonate by mouth or sixth-molar (M/6) sodium r-lactate (1000 to 2000 cc.) intravenously until the urine is alkaline (a pH higher than 7.5). (See section on alkalies in the treatment of shock.)

Blood Loss Factors. (See Treatment of Shock.)—In addition to cases of postoperative shock or blood loss resulting from operation, administration of blood is often indicated in a protracted convalescence to supply hemoglobin, protein or antibodies. Plasma is useful to supply protein or correct hemoconcentration (see the section on burns).

The amount of blood lost in ordinary operations is almost always greater than the surgeon estimates it to be, according to Coller and Maddock.[131] Coller et al.[132] say: "No easy, practicable laboratory procedure will indicate the status of the circulating blood in the postoperative patient." They conclude: "Whole blood is required adequately to replace blood lost during surgical operations. The replacement is most effective when whole blood is given as the loss occurs. The amount of blood needed in each surgical case can seldom be determined directly. Hemoglobin, hematocrit, and plasma protein concentrations fail as an accurate measure of this need. Plasma volume determinations are more accurate, but are too laborious and time consuming for routine use. A knowledge of blood loss during operation as available in the literature offers a practical basis for planned transfusions during operation."[133]

Food Needs (Caloric and Nitrogen Requirements).[133a]—*Dextrose.*—In the average case the caloric requirements are negligible until the patient is able to take food by mouth. However, water is usually given parenterally in 5 per cent dextrose, and a definite though small amount of calories is thus supplied.

Paine[134] says: "Winslow[135] has shown recently that although the major portion of the dextrose injected intravenously in 5 or 10 per cent solution is held by the body whatever the rate of the injection, for full utilization of the dextrose and for decreasing the diuretic effect of its injection to a minimum administration must be made at a relatively slow rate These optional slow rates of injection, however, are often difficult to achieve in a busy

hypodermoclysis "

In this connection Ravdin[136] says:

"It should be pointed out that the food intake should be in excess of the energy requirements of the patient if visceral storage is to be effected This cannot now be accomplished

* Supplied by Eli Lilly & Co., Indianapolis, Ind.

regeneration that takes place under such circumstances must obtain its protein from endogenous sources." As soon as possible it is desirable that the patient take food orally. The types and amounts of food vary widely with different operations.[137]

Protein.—The great importance of protein in surgical convalescence has only recently been appreciated. Blood plasma is composed of a number of different proteins. Of these, albumin is the only one of surgical significance because it is the fraction most frequently depleted and because it contributes 85 per cent of the colloidal osmotic pressure. Depletion of albumin is responsible for most of the clinical manifestations. Elman and Lischer[138] prefer the term *hypoalbuminemia* to *hypoproteinemia* in referring to plasma protein deficiencies. Hypoproteinemia may result from eating an insufficient amount of protein (malnutrition), from excessive loss of plasma proteins (injuries, burns, loss into the peritoneal cavity in cases of general peritonitis and intestinal obstruction), from excessive loss of nitrogen in the urine in conditions causing extensive destruction of plasma protein and tissue protein (thyrotoxicosis, abdominal operations, fractures, burns) and defects in albumin synthesis (hepatic disease). Elman[139] says: "Much of the caloric need may safely be sacrificed provided adequate protein is furnished." According to the Committee on Convalescence and Rehabilitation of the National Research Council,[140] the average requirement for the sick or injured patient is 100 to 150 Gm. of protein daily. They say: "Nothing less than 1 Gm. of protein per kilogram of body weight per day can be regarded as a safe subsistence ration for a normal adult." Meyer and Kozoll[141] found hypoproteinemia occurring most frequently in cases of bleeding peptic ulcer, carcinoma o fthe gastrointestinal tract, bowel obstruction and intestinal fistula.[142]

Hypoproteinemia may be the cause of many symptoms. In a sense, surgical *shock* may be thought of as a manifestation of acute hypoproteinemia. *Suppression of urine* in a surgical case may be due to "an inability to maintain fluid balance because of an unsuspected hypoalbuminemia."[138]* *Hemoconcentration* due to plasma dehydration, in distinction from mere loss of water and salts, is associated with hypoproteinemia (burns, abdominal operations, intestinal obstruction, general peritonitis). "Unexplained *abdominal distention* after operation may be due to postoperative hypoalbuminemia, which is due in turn to an edema of the viscera, precipitated by the trauma of the operative procedure." Ravdin[136] says: "Hypoproteinemia may give rise to so intense an edema following a gastro-intestinal anastomosis as to mimic in every way a mechanical defect of the technic of anastomosis. The impediment to normal gastro-intestinal flow is frequently the result of an accentuation and prolongation of the edema associated with hypoproteinemia by the trauma of operation. In the presence of a lowered colloid osmotic pressure of the plasma, fluids cannot normally find their way back into blood vessels, the size of the new stoma is reduced, and the area made more rigid by extensive fluid extravasation." Moreover, there is evidence that distention itself may lead to hypoproteinemia. *Peripheral subcutaneous edema* may be due to hypoproteinemia (nutritional edema) as well as to cardiac and renal causes. Nutritional edema is a late manifestation of hypoproteinemia. *Ascites*, although largely caused mechanically (portal obstruction), may be partly due to hypoproteinemia. *Faulty wound healing* is often seen in hypoproteinemia, although many other factors play a part. (See section on vitamin C.)

* The following paragraphs are largely based on the article by Elman and Lischer.[138]

When hypoproteinemia is suspected clinically, chemical examination of the blood is carried out. The normal plasma protein value is about 7.0 Gm. per cent. The chemical examination should fractionate the plasma protein into albumin and globulin, as it is the former which is most useful in determining plasma protein deficiency. The albumin values must be checked with the red cell count or hematocrit values to eliminate false values due to dehydration.[143]

Treatment of hypoproteinemia consists of replacement of protein or the amino acid components of protein. (*a*) A *high protein diet* is indicated, consisting of proteins rich in essential amino acids: milk (without cream), cottage cheese, lean meats, liver, pancreas, egg proteins, particularly egg albumin, and soy bean protein. The National Research Council feels that an adequate protein intake for adults is 1 Gm. per kilogram of body weight. Amigen may be given orally. A protein-depleted patient should be given 1.5 to 3 Gm. per kilogram per day. A level tablespoonful is approximately 9 Gm. The taste is improved by mixing amigen with grape or lemon juice, 0.5 per cent salt or carbonated fruit juices.[144] Amino acids can be given in the form of hydrolyzed casein by mouth in fruit juices or by nasal catheter (see section on injection of casein hydrolysate). (*b*) *Plasma transfusions* should be given early in shock, severe hemorrhage and burns and in sufficient amount. In severe cases 1,000 cc. should be given as soon as possible and much larger quantities as indicated by the clinical condition and blood findings (see section on sternal infusion). In chronic hypoproteinemia large quantities of plasma may be used. It is possible to use ascitic fluid.[145]

(*c*) *Intravenous Injections of Amino Acids* (*Casein Hydrolysate: Amigen**).—Elman and Lischer[138] say: "With increasing knowledge of protein deficiencies, this method of parenteral therapy will probably become as frequent as the use of saline and glucose solutions. Indeed, if a patient needs intravenous injections of glucose he needs intravenous injections of amino acids even more, inasmuch as the former can be made easily from the latter, whereas there is no substitute for the nitrogenous amino acids. Moreover, tissue fat, which is easily dispensable, supplies over twice as much calories per gram as glucose." Madden et al.[146] say that "proper mixtures of amino acids are capable of providing the protein nitrogen requirements of man and animals over long periods of time." Brunschwig[147] points out that the terms amino acids and "casein" or "protein" digests should not be used interchangeably. He says: "A solution of amino acids is just that and is prepared by addition of these acids each in crystalline form obtained synthetically or by extraction. A protein may be decomposed to its constituent amino acids but the writer is unaware of a digest generally available at this time in which this has been accomplished. The several types of available digests represent mixtures of simple peptids *and* amino acids. It has not yet been demonstrated that utilization of intravenously administered digests and solutions containing only amino acids are identical phenomena. Indeed, it has not yet been determined which type of preparation is the most desirable." Severe liver impairment will contraindicate the administration of amino acids. For routine use, 5 per cent

amigen in 5 per cent glucose is recommended. A liter of amigen contains 3 Gm. of sodium chloride. "A liter of such a solution contains 6 Gm. of nitrogen and thus strictly speaking the equivalent of but 37.5 Gm. of protein, which is usually 16 per cent nitrogen. Two liters per day, therefore, is required to meet the basic demands (1 Gm. per kilogram per day) of a normal man for protein. If solutions of casein hydrolysate are properly prepared, they should provoke no pyrogenic reactions. If they are injected too rapidly (faster than 500 cc. of a 5 per cent solution per hour in an adult of normal size), nausea or vomiting may be induced."[140] The calculated protein requirement should be multiplied by 1.3 to obtain the amigen requirement. For example, if 2 Gm. of protein per kilogram of body weight is desired, 52 cc. of 5 per cent amigen in 5 per cent dextrose per kilogram of body weight should be given ($2 \times 1.3 \times 20$). Elman[148] says that if a mixture of 5 per cent amino acids with 5 per cent glucose is diluted with an equal quantity of distilled water, it may be administered subcutaneously. Davis[149] recommends the routine use of intravenous protein digest after major operations. Kozoll et al.[150] were able to achieve nitrogen balance in 13 of 14 cases of obstructing lesions of the esophagus or stomach by using parenteral injections of amino acids as the only source of protein. About half the nitrogen of the amino acids is utilized. Not more than 25 Gm. (500 cc. of 5 per cent solution) should be given. Elman and Lischer have given as much as 300 Gm. of amigen in twenty-four hours.[151] Brunschwig et al.[152] have maintained a patient solely on intravenous administrations for 46 days. Brunschwig and Nichols[153] say that "gelatin injected intravenously constitutes one method by which nitrogenous material may be administered to the organism."[154]

In some cases it is possible to maintain nutritional feedings with a Miller-Abbott tube.[155] For this purpose Scott's pabulum (668 calories and 31.6 Gm. of protein per quart) and "St. Mary's formula" are useful. In regard to postoperative feeding see Kiefer,[156] Lawrence and Connick[157] and Hansen.[158]

Vitamins.—See the section on vitamins under Preoperative Care.

Oxygen.—Oxygen has several important uses in the postoperative period.[159] It is of value when patients have a poor circulation and a rapid pulse and after thyroidectomy for thyrotoxicosis. Schnedorf and his associates,[160] in discussing the use of oxygen in the postoperative care of patients with hyperthyroidism, say: "Anoxemia is present long before cyanosis becomes visible. Oxygen therapy is indicated in the postoperative treatment of patients with toxic goiter because they showed a postoperative anoxemia and because they utilize more oxygen than the normal patient." It is also a useful adjunct in diminishing abdominal distention.[161] It may be given by nasal catheter, Boothby mask or oxygen tent or even subcutaneously.[162]

Early Ambulation.—The author of this book has come to feel that early ambulation is a distinct step forward in postoperative care. With the increasing employment of transverse abdominal incisions and silk suture material, early ambulation is not only safe but it adds greatly to the patient's comfort, shortens his convalescence and minimizes postoperative complications. In a most interesting paper, Dock[163] points out the fact, "now fully confirmed by precise studies in many laboratories, that *the cardiac output and the work of the heart are increased by changing from the sitting to the lying position.*"[164] Dock adds: "When recumbent the heart is carrying a load definitely greater than during a sedentary existence, and the rate of edema accumulation in the lungs,

the brain and in other tissues of the thorax and head is also greater. After an operation on the head and neck, or after trauma or a stroke, *swelling of the tissues* will occur most rapidly and to the most marked degree if the patient is allowed to lie flat; it will be minimal if he sits up with feet dependent."

To achieve early ambulation, the patient sits on the edge of the bed with his feet down on the first or second day after operation, and if possible he stands for a few minutes. This is carried out two or three times daily, and walking is gradually instituted as soon as possible.

In an excellent paper Blain and Kanar[165] state that early postoperative ambulation has the following advantages: 1. It is an effective measure in preventing pulmonary complications. 2. It decreases the incidence of thrombosis and embolism. 3. It promotes efficient lymphatic and venous drainage. 4. It diminishes or relieves gastrointestinal disturbances, such as anorexia, nausea, vomiting, "gas pains" and dilatation of the stomach. 5. It reduces the incidence of urinary retention. 6. It may reduce the possibility of troublesome adhesions. 7. It improves muscle tone. 8. It is thought to improve wound healing. 9. It simplifies nursing care. 10. It shortens the time of the patient's hospitalization. 11. It shortens the patient's total convalescent time. 12. It benefits the patient's morale. Blain[166] says that contraindications to early ambulation are shock, hemorrhage and major infections. Nixon[167] considers the following to be contraindications: drains in situ, elevation of temperature, indwelling duodenal tube, marked anemia, hemorrhage, and peritonitis and other cases of potential peritonitis, such as puncture wounds of the abdomen.

Interest in this subject in the United States was aroused by the paper written by Leithauser and Bergo,[168] based on 484 cases of early ambulation. The method has been carefully studied and endorsed by Schafer and Dragstedt,[169] Nelson[170] (426 cases), Ashkins[171] (823 cases, with no complications due to early ambulation), Powers[172] (100 cases), Blodgett and Beattie[173] (681 cases), D'Ingianni[174] (303 cases), Rickles[175] (146 cases), McDonough[176] (304 cases) and Spang and Spang[177] (150 cases). Blodgett and Beattie found a somewhat higher incidence of deep leg thrombophlebitis in cases of early ambulation. Canavarro[178] is strongly in favor of early ambulation after comparing 500 cases at the Presbyterian Hospital, New York, in which there was early ambulation, with 500 cases in which there was not early ambulation.[179]

Postoperative Complications.—*Surgical Shock.*—(See the section on shock and its treatment.)

Thirst.—(See the section on dehydration.)

Vomiting.—The ordinary postoperative vomiting usually subsides after a few hours. During this period it is preferable to withhold fluids orally. Washing the patient's mouth with liquor antisepticus or ice water is comforting. Ice chips may be held in the mouth. When the vomiting is protracted and the vomitus becomes darker in color, the surgeon should give careful attention to the etiology of the condition and its treatment.

Dilatation of the Stomach.—This serious and sometimes fatal complication requires prompt recognition and treatment.

According to Dragstedt *et al*,[180] the outstanding features are the "sudden and often [illegible] pro- [illegible] ns of [illegible] thors [illegible] leath

in acute dilatation of the stomach. The dilatation is held to be due to reflex inhibition of the peripheral gastric motor mechanism through efferent impulses reaching the stomach by way of the vagi and splanchnics. Experimental evidence is adequate to show that the stimulation of either visceral or somatic sensory nerves may produce such reflex gastric inhibition. The dilatation of the atonic stomach is produced by swallowed air and the accumulating secretions of the stomach and duodenum. The fluid is made up of gastric and pancreatic juice, bile, and the secretions of the upper duodenal mucosa. From some recent observations on the normal volume of the digestive secretions in the dog, which indicate that previous estimates have been far too low, even the large amounts found in acute dilatation of the stomach do not seem excessive or the result of abnormal secretion. The cause of death is the failure of reabsorption of gastric and pancreatic juices, and more particularly of the inorganic elements, sodium and chlorine, excreted in these fluids. The failure of reabsorption in turn depends upon the inability of the atonic stomach and duodenum to propel these secretions into the lower intestine where their absorption can take place. The gastric and duodenal mucosa does not absorb these digestive juices. In certain cases a secondary mesenteric obstruction to the inferior horizontal portion of the duodenum occurs and provides a further obstacle to the passage of the secretions into the lower bowel. In the clinical case reported the patient developed an hypochloremia alkalosis and dehydration exactly as occurs in the experimental animal when the gastric juice secreted is not allowed to be again absorbed. It is probable that the occasional symptoms of tetany observed in cases of acute dilatation of the stomach are due to the alterations in the blood chemistry as a result of the failure of reabsorption of gastric juice."

Beck[181] says: "Acute gastroduodenal dilatation is usually due to an obstruction of the duodenum by compression of this organ between the superior mesenteric artery and the vertebral column and aorta. It occurs in the debilitated or emaciated patient who is forced to lie on his back."

Dilatation of the stomach is generally characterized by persistent vomiting, generally of material of dark brown color. Often the earliest symptom is nausea. Sometimes, however, *there may be no vomiting* but mere distention of the abdomen, with increase in the pulse rate. Even abdominal distention may be absent. Hiccoughs may be an early symptom. The patient may continue to drink normally. Abdominal distention may be present and mistaken for tympanites and treated by ill advised stuping and enemas. *In all cases in which abdominal distention is suspected, the stomach tube should be passed.* When the diagnosis is confirmed by the finding of an accumulation of fluid within the stomach, the latter should be kept empty by lavage, done every three or four hours, or even every hour, night and day, until the washing remains clear. *Very much preferable to periodic lavage is the Wangensteen continuous suction with the Levin catheter.*

To perform lavage properly a certain amount of skill and tact is necessary. The intern first should explain to the conscious patient that while the lavage is disagreeable it is by no means insupportable and that the greater the degree of cooperation, the less discomfort he will have. The patient is properly draped about the neck with a rubber sheet and a towel. The lavage tube has been prepared by the nurse so that it is immersed in ice water. Some surgeons advise lubricating it with glycerin before passing it. The patient may be propped up on a moderately elevated backrest and instructed to open his mouth. The tip of the lavage tube is placed in the posterior part of the pharynx, with the inclination downward. The patient is instructed to swallow, and as he does so, the tube is rapidly forced down the esophagus until the proper black line marking reaches the incisor teeth. Many patients at this juncture will think that they are becoming asphyxiated and will [illegible]

bulb should be attached to the outer end and efforts made to aspirate [illegible]
any fluid which m[illegible]
warm dilute soluti[illegible]
to the stomach tu[illegible]
aspirated. In place of the aspirating bulb a funnel may be attached to the outer end of the avage tube and the solution poured in by means of a pitcher. The aspiration of the stomach

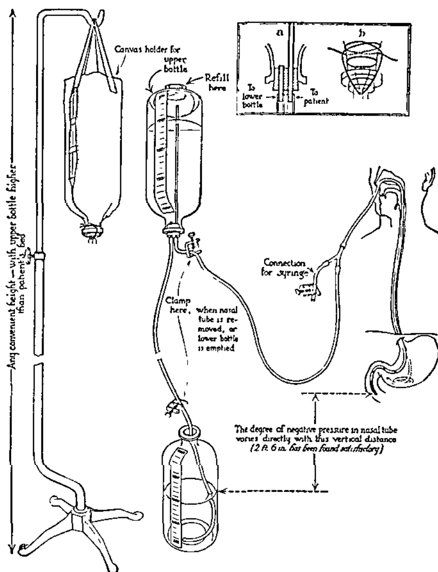


Fig. 577.—*Wangensteen Suction Apparatus* Diagram of suction apparatus used in treating postoperative distention, nausea, and vomiting and certain cases of mechanical bowel obstruction; a special, heavy tipped (rubber of higher specific gravity) duodenal tube with perforations continued back 9 or 10 inches is employed. A Y tube connection is attached to the proximal end of the duodenal tube for purposes of irrigation to facilitate freeing it from plugs of mucus which may occasionally interrupt the suction action. (Paine, J. R., and Wangensteen, O. H.: Surg, Gynec. & Obst. 57: 601, 1933.)

by this method is accompanied merely by lowering the funnel below the level of the stomach, when the siphon action causes the emptying of the stomach through the lavage tube. It may be necessary to withdraw and insert the tube a little to insure free flow. In order to prevent spilling into the trachea the contents of the lavage tube when it is removed, the

In unconscious patients the head will be turned to the side, and similar care will be observed in the withdrawal of the tube so as not to permit the stomach contents to enter the trachea.

The author has been employing the *nasal gastroduodenal catheter* (*Levin tube*[182]) in place of the stomach tube in cases of dilatation of the stomach and peritonitis. This is a long rubber catheter of 12 F., 14 F [illegible]
or may not be used. [illegible]
distance to the stom[illegible]
and passed into the nostril. With very little discomfort it quickly passes the nasopharynx and the esophagus and enters the stomach. It is important not to pass the catheter too far, because there is some likelihood of its entering the duodenum. After the catheter has been inserted for the proper distance, it is anchored to the cheek with adhesive plaster. The outside end may hang over the edge of the bed into a bottle. The tube is left in place as long as necessary, even four or five days. If the nostril becomes sore, the tube may be changed to the opposite side. By means of this tube all of the excess fluid which is regurgitated into the stomach may be quickly and easily removed, either by siphon action with the tube hanging in the bottle or by periodic aspiration. Aspiration is generally done with a 50 cc. Luer syringe. If a small solid particle blocks the tube, the difficulty generally is remedied by injecting a small quantity of salt solution or water. If lavage of the stomach is desired, it may be done by washing in and out of the tube an appropriate solution (water, saline or soda bicarbonate solution). A better way, however, is to let the patient drink a large glass of water immediately before or during the aspiration. The drinking permitted in this way affords the patient a great deal of comfort.

Of recent years in cases of dilatation of the stomach, the author has entirely discarded periodic stomach aspiration and siphonage drainage in favor of the Wangensteen continuous suction apparatus. The nasal catheter is easily passed if lubricated and is tolerated by the patient for days. The patient may drink as much as he wants as it is promptly returned. The mouth is kept thoroughly moist. Large amounts of fluid and gas are removed from the stomach and the jejunum, and each may be measured carefully by this apparatus (Fig. 577). It is important that all rubber connections of the Wangensteen apparatus be air tight, as the slightest leakage of air will invalidate the measurement of aspirated gas. It is equally important that a careful record be kept of the oral intake during Wangensteen suction so that the amount of aspiration or absorption can be computed. A simple form for the nurse's chart has been developed at the Evanston Hospital (Fig. 578). In this chart the term "fluid intake" refers to oral fluid intake and is not concerned with parenteral fluids. In cases of dilatation of the stomach it is important to observe the color of the aspirated contents. When this finally becomes lighter in color and clearer, the suction may be clamped off, to be opened for three to five minutes every half hour to hour to ascertain whether or not the stomach has begun to take care of the swallowed fluid.[183] If the suction tube becomes clogged with stomach contents, it can be irrigated through the side connection. The amount of fluid introduced for irrigation must be included in computing the final figures. Taylor,[184] in reporting a fatal case of alkalosis resulting from nasal tube gastric suction, emphasizes that the chlorides removed by suction must be fully covered by intravenous saline solution. Prolonged use of Wangensteen suction by nasal catheter is not without danger of damaging the esophagus or the larynx. Iglauer and Molt[185] have reported on 10 cases in which there was laryngeal damage, tracheotomy being required in 8 instances. Holinger and Loeb[186] describe stenosis of the larynx from pressure of the tube. when left in the center [illegible] om
one si[illegible] the
mouth [illegible] [188]

Ileus (*Abdominal Distention*).—Ileus may be defined as inadequacy or absence of intestinal movements and may be adynamic ("paralytic") or mechanical. Both types occur in the postoperative period, but "paralytic ileus" is more common. Diagnosis of postoperative mechanical obstruction may be difficult to distinguish from the postoperative ileus which often precedes it.[189] Mechanical obstruction usually requires prompt operation. Postoperative "paralytic ileus" commonly occurs in cases of peritonitis and is accompanied by distention of the abdomen, tympanites, failure to pass gas and often vomiting. The gas in the distended stomach or intestine is largely swallowed air. The "flat" x-ray film will show gas-filled loops of small bowel with fluid levels. In cases of postoperative ileus there are no signs of peristalsis in the roentgenogram.[190]

EVANSTON HOSPITAL ASSOCIATION

WANGENSTEEN SUCTION

NAME George Watson WARD C III ROOM 26 NO. 144862

DATE	TIME STARTED	UPPER BOTTLE C C	LOWER BOTTLE C C	FLUID INTAKE* C.C	TIME CHANGED	UPPER BOTTLE C C	LOWER BOTTLE C C	AMOUNT ASPIRATED C C	AMOUNT ABSORBED C C	GAS C C.	NURSE
6-26-46	1:30pm	3000	500	1200	4:30pm	2100	4900	1400	0	900	Barrett
6-26-46	4:30pm	3000	500	1000	6:00pm	1500	3600	900	0	1200	Barrett
6-26-46	6.00pm	3000	500	1300	8:30pm	1700	3600	600	0	1300	Barrett
6-26-46	8.30pm	3000	500	800	11:00pm	1100	3400	100	0	1900	Leach
6-26-46	11.00pm	3000	500	900	1:30am	1800	2600	0	0	1200	Leach
6-27-46	1:30am	3000	500	700	5.00am	2200	1750	0	250	800	Leach
	Tube clamped except for 5 minutes out of every 30 minutes										
6-27-46	5:00am	3000	500	200	8 00am	2100	1300	0	300	900	Leach
6-27-46	8:00am	3000	500	400	11.50am	2400	900	0	600	600	Leach
	Tube removed.										

REMARKS I E, NATURE OF ASPIRATION, ETC.

6-26-46 4 30pm Dark brown fluid with black flecks

6-26-46 11:00pm Yellow transparent fluid

*Fluid intake includes oral intake and tube irrigation intake

Fig 578.—Form used at Evanston Hospital for keeping record of Wangensteen suction apparatus Schematic representation of treatment for dilatation of the stomach.

A useful agent in the treatment of this condition is the *Wangensteen gastric suction apparatus.* (See the previous section.) The indwelling catheter should be in the stomach to be effective, although its usefulness is definitely greater if it enters the duodenum. It is thought that if the gas is removed from the stomach, gas at higher pressure in the duodenum will return to the stomach Similarly, gas in the jejunum will return to the duodenum, so that by means of suction in the stomach the entire small bowel may often be decompressed.[191]

[illegible] abdominal distention, [illegible] has given advice [illegible] ives the following *directions for its introduction:*

"Under these circumstances it is not difficult to pass the tube through the nose and into the stomach. Before the tube is passed a measurement should be taken to determine roughly how far the tube must be passed through the nose to make the tip approach the pylorus. With the bag fully deflated and lubricated with mineral oil, the tube is started through the nose which may be cocainized. If the patient is cooperative, the end is passed into the stomach with a few swallows of water which can be immediately aspirated, giving assurance that the tip has reached the stomach. The tube is passed to a point where the end is about 4 inches short of the estimated distance to the pylorus. It is then tied at the nares with a cloth tape anchored to the nose and lip with adhesive. The use of the tape to hold the tube prevents the adhesive material from sticking to its rubber walls and facilitates freeing the tube for further introduction.

"The most important and difficult procedure is to accomplish the passage of the tip of the tube through the pylorus. The special value of the therapy depends upon the success of this step. We have had more satisfactory results by applying suction to the stomach for several hours before attempting to pass the tip of the tube into the duodenum. The theoretical basis for this procedure is that when the dilatation is relieved, the stomach may be better able to regain its muscular tone and peristalsis which carries the tube through the pylorus. It is important to have the patient lie upon his right side to direct the end of the tube toward the antrum. Sips of clear fluid are allowed by mouth. After four hours about one inch of the tube is introduced through the nose every half hour until one more foot of tubing has been passed into the stomach. This step is designed to permit the tip to approach the pylorus slowly and to be carried into the duodenum, and not to allow the tube to coil

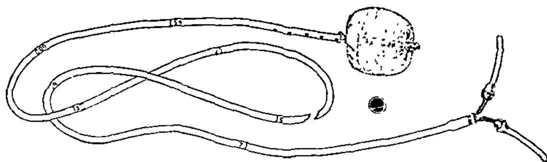


Fig. 579 —Diagram of the double lumen Miller-Abbott tube. (Blodgett, J. B.: Am. J. Surg. *53: 271, 1941.*)

in the stomach as a result of many inches of tubing being introduced at once. Coiling of the gastric segment of the tube resulting from too rapid introduction has been repeatedly demonstrated fluoroscopically.

"After the foot of tube has been introduced slowly, an *x*-ray check *should* be made to determine whether the tip has entered the duodenum. If this has not occurred, [illegible]

"C [illegible]
deter [illegible]
plain [illegible]
the b [illegible]
point [illegible] of the tube. . . . After the bag is properly inflated, it has been reported that the tube may be carried along the jejunum at a rate of approximately two feet an hour. One foot an hour is accepted as a reasonable clinical expectation. In our cases the tube has been introduced through the *nose* at a rate of six inches every half hour. This is accomplished by lubricating six or eight inches of the tube at the nose, which is passed as the patient takes several swallows of water. The tube is introduced in this manner until it has passed to its full length, or until the tip is demonstrated by *x*-ray to have reached either the obstruction or the ileocecal junction. Wangensteen suction through *collecting bottles*

Ileus (Abdominal Distention).—Ileus may be defined as inadequacy or absence of intestinal movements and may be adynamic ("paralytic") or mechanical. Both types occur in the postoperative period, but "paralytic ileus" is more common. Diagnosis of postoperative mechanical obstruction may be difficult to distinguish from the postoperative ileus which often precedes it.[189] Mechanical obstruction usually requires prompt operation. Postoperative "paralytic ileus" commonly occurs in cases of peritonitis and is accompanied by distention of the abdomen, tympanites, failure to pass gas and often vomiting. The gas in the distended stomach or intestine is largely swallowed air. The "flat" x-ray film will show gas-filled loops of small bowel with fluid levels. In cases of postoperative ileus there are no signs of peristalsis in the roentgenogram.[190]

EVANSTON HOSPITAL ASSOCIATION

WANGENSTEEN SUCTION

NAME George Watson WARD C III ROOM 26 No. 144862

DATE	TIME STARTED	UPPER BOTTLE C C	LOWER BOTTLE C C	FLUID INTAKE* C C	TIME CHANGED	UPPER BOTTLE C C	LOWER BOTTLE C C	AMOUNT ASPIRATED C. C	AMOUNT ABSORBED C. C	GAS C. C.	NURSE
6-26-46	1:30pm	3000	500	1200	4:30pm	2100	4000	1400	0	900	Barrett
6-26-46	4:30pm	3000	600	1000	6:00pm	1800	3600	900	0	1200	Barrett
6-26-46	6:00pm	3000	500	1300	8:30pm	1700	3600	800	0	1200	Barrett
6-26-46	8:30pm	2000	500	800	11:00pm	1100	3400	100	0	1900	Leach
6-26-46	11:00pm	3000	600	900	1:30am	1800	3600	0	0	1200	Leach
6-27-46	1:30am	3000	500	700	5:00am	2200	1750	0	250	800	Leach
	Tube clamped except for 5 minutes out of every 30 minutes										
6-27-46	5:00am	3000	500	200	8:00am	2100	1200	0	300	900	Leach
6-27-46	8:00am	3000	500	400	11:50am	2400	900	0	600	600	Leach
	Tube removed										

REMARKS I. E., NATURE OF ASPIRATION, ETC.

6-26-46 4:30 pm Dark brown fluid with black flecks

6-26-46 11:00 pm Yellow transparent fluid

*Fluid intake includes oral intake and tube irrigation intake

Fig. 578.—Form used at Evanston Hospital for keeping record of Wangensteen suction apparatus Schematic representation of treatment for dilatation of the stomach

A useful agent in the treatment of this condition is the *Wangensteen gastric suction apparatus*. (See the previous section.) The indwelling catheter should be in the stomach to be effective, although its usefulness is definitely greater if it enters the duodenum. It is thought that if the gas is removed from the stomach, gas at higher pressure in the duodenum will return to the stomach. Similarly, gas in the jejunum will return to the duodenum, so that by means of suction in the stomach the entire small bowel may often be decompressed.[191]

Wh [illegible] distention, *the M* [illegible] advice as to [illegible] llowing directions for its introduction:

"Under these circumstances it is not difficult to pass the tube through the nose and into the stomach. Before the tube is passed a measurement should be taken to determine roughly

stomach with a few swallows of water which can be immediately aspirated, giving assurance that the tip has reached the stomach. The tube is passed to a point where the end is about 4 inches short of the estimated distance to the pylorus. It is then tied at the nares with a cloth tape anchored to the nose and lip with adhesive. The use of the tape to hold the tube prevents the adhesive material from sticking to its rubber walls and facilitates freeing the tube for further introduction.

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tube toward the antrum. Sips of clear fluid are allowed by mouth. After four hours about

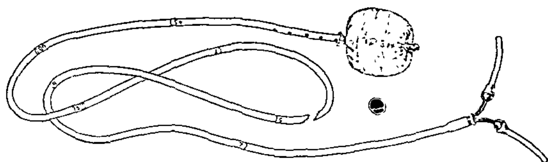


Fig. 579 —Diagram of the double lumen Miller-Abbott tube. (Blodgett, J. B.: Am. J. Surg. 53: 271, 1941.)

in the stomach as a result of many inches of tubing being introduced at once. *Coiling of* the gastric segment of the tube resulting from too rapid introduction has been repeatedly

once the tube has become coiled in the stomach the tip has never been demonstrated to have passed the *pylorus, and there* is definite danger of the formation of a figure eight or overhand knot in the coiled tubing. Failure to recognize that the tube is not passing into the duodenum results in a delay of small intestinal intubation which

"C

deter only certain way of

plair has been determined tha

the bag is inflated with 30 cc. of air. *Too early*

point results in regurgitation of the tube. . . . After the bag is properly inflated, it has been reported that the tube may be carried along the jejunum at a rate of approximately

is maintained while the tube is passing along the small intestine. The most rapid passage of the tube to the cecum was observed in a period of eighteen hours. In peritonitis it may be a matter of days. The progress of the tube can be halted at any time by deflating the balloon. The tubing should not be allowed to coil in the stomach as loops may prolapse into the duodenum and obstruct free suction by kinking the tube."

The following account of the employment of the Miller-Abbott tube at the Presbyterian Hospital, New York, has been supplied through the courtesy of Dr. Earl Sanborn: "The past eight to nine years have seen the acceptance of the Miller-Abbott tube as an essential adjunct for the diagnosis and treatment of lesions of the small and large intestines in some hospitals.[194] As a result small bowel obstructions and some sites of cryptic bleeding from the gastrointestinal tract have been located and their character ascertained. If necessary, diluted barium fluoroscopy and roentgenograms have been used. As a means of prophylaxis in the prevention of paralytic ileus in cases of peritonitis, etc., in eliminating tension on the suture line of an intestinal anastomosis, the tube being passed either preoperatively or postoperatively, and in forestalling postoperative distention, its use has been repeatedly demonstrated. *Therapeutically it has become the treatment of choice in certain cases of* [illegible] of [illegible] age [illegible] the stomach preoperatively in cases of suspected internal hernia, intussusception, volvulus and mesenteric thrombosis is sufficient. At operation it may be possible to pass the end of the tube manually through the pylorus and thus accelerate its passage to the small intestine.

"*Technic of Passing the Miller-Abbott Tube.*—After the double-lumen balloon-tipped tube has been tested to make certain that it is patent, intact and without leaks, the nasal passages of the patient are tested for patency. The larger and more patent passageway is partially anesthetized (with 2 per cent cocaine or butyn) along with the pharynx. With the patient in as near a sitting position as possible and breathing through his mouth, the well lubricated (K-Y jelly or petrolatum) balloon, which is folded like an umbrella over the tip of the tube, is passed through the nostril to the nasopharynx. As the patient intermittently swallows water, the tube is advanced to the stomach (the 60 cm. mark). Suction with a syringe attached to the suction-lumen tube is made, and the stomach is emptied of fluid and air. The tube is then passed on to the 75 cm. mark and fastened to the nose with adhesive tape before further suction is applied to remove any residual air or fluid. Two or

is an indication for the tube to be advanced slowly. In paralytic ileus the progress of the tube is less rapid. The weight of the mercury alone often will "pull" the tube quite rapidly through the intestine.

"Constant care of the patient with a Miller-Abbott tube continues to be important when it has passed the pylorus. Mineral oil swabbing of the nasal passages and analgesic lozenges and sprays give the patient some comfort. The nasopharyngeal portion of the tube should be cleaned, oiled and replaced daily. Repeated abdominal examinations should be made.

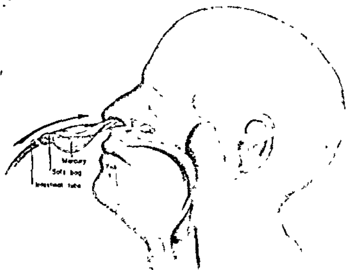


Fig. 580 *a*.—Single-lumen mercury-weighted intestinal tube in position for insertion. Note mercury in proximal end of twisted lubricated bag.

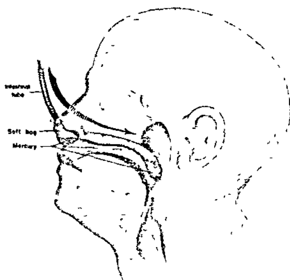


Fig. 580 *b*.—Tube is elevated in order to allow mercury automatically to flow into empty nasopharyngeal end of bag. (Harris, F. I.: Surg., Gynec. & Obst. 81: 671, 1945.)

Gastric dilatation may occur, and relief can be obtained with

fluid intake and output records are essential. Parenteral fluids, including electrolytes, vitamins, proteins and transfusions, may be necessary. The presence of a Miller-Abbott tube in a patient is no contraindication to early ambulation; continuous suction can be maintained while the patient is sitting in a chair or interrupted while he is walking.

"The tube is advanced until any obstruction is met or passed, the cecum is reached, or all of the diagnostic and therapeutic possibilities of the tube have been utilized. If the tube is to be left at any definite level, the balloon is deflated and the tube kept at that point by being fastened to the nose with adhesive tape."

Smith[196] has reviewed 1000 cases in which the Miller-Abbott tube [illegible] terian Hospital, New York. The tube was found [illegible] were 11 instances of serious complications an[illegible] was unsuccessful.

The single-lumen mercury-weighted tube des[illegible] by Harris[197] is promising (Fig. 580 *a* and *b*).[198]

Various types of tubes have been devised for indwelling suction. After gastric resection the forked or Y tube of Wangensteen is valuable.[199] The simultaneous gastroduodenal double lumen aspirator of Einhorn[200] is useful.

In the past, external heat in the form of hot stupes was used, but after careful studies Bisgard and Nye[201] have concluded that "gastrointestinal motor activity is inhibited by the application of heat to the abdominal wall and by iced water taken by mouth. It is stimulated by the application of ice to the abdominal wall and by the ingestion of hot water by mouth."[202] Occasionally there is some benefit from the employment of various types of enemas (soapsuds, "1, 2, 3" [glycerin, 1 part; magnesium sulfate, 2 parts, and water, 3 parts], milk and molasses, oxgall and turpentine, etc.), and, as suggested by Dr. Carl B. Davis, of Chicago, a senna infusion enema.

The author has had a patient who, following an operation for bilateral inguinal hernia, had such great distention of the colon that the cecum perforated. Recovery followed repair of the perforation. He has heard of a similar case (Dr. R. C. Webb, Minneapolis).[203]

After an extensive experimental study of the value of drugs in the relief of ileus, Ochsner *et al*[204] reached the conclusion "that drug therapy for intestinal atony rests on a rather precarious foundation. . . ." They say that "*pituitary extract would not only seem to be an ineffective drug in the treatment of intestinal atony, but also would appear to be a dangerous drug in such a condition.*" After a study of patients, Puestow[205] said:

"A contrary motility between small and large bowel has been noted. When the small bowel is vigorously contracting, the colon is inactive. When the colon contracts, the small intestine appears to be inhibited. Those drugs, including the opiates, physostigmine, prostigmine methylsulfate and the choline derivatives, which stimulate motility of the small bowel inhibit the colon. Solution of posterior pituitary and pitressin produce powerful contractions of the colon but diminish motility of the small bowel. Postoperative distention may be due to the paralyzing action of morphine on the colon."

Adler and his associates[206] say:

"It is believed that a combination of ergotamine tartrate (0.25 mgm.), prostigmine methylsulfate (0.25 mgm.), and pituitrin (1.25 units) should prove to be more effective in the management of postoperative distention than any of the drugs used alone. On the basis of duration of action, the absence of side reactions with doses which are effective in producing strong propulsive motility, prostigmine is ranged as the best single drug yet investigated "[207]

Attention has been attracted to the employment of sodium chloride solutions to stimulate peristalsis. Orr, Johnstone and Haden[208] note that their "experiments confirm the observation of others that hypertonic sodium chloride solutions stimulate peristalsis." Orr[illegible] s,

hour after the salt was given. In only one instance did a patient state that no relief was obtained by the treatment. Some patients noted relief before the intravenous injection was completed. In some cases a second or third injection was necessary before complete relief was obtained."

Fine, Hermanson and Frehling[210] have found that "the inhalation of 95 per cent oxygen, according to a technic previously described, provides an effective method for deflation of the distended intestine when other non-operative measures fail."

It is probable that morphine is not contraindicated in cases of ileus provided the rectal sphincter is kept open by rectal tube or enemas. Orr and Carlson[211] say: "Morphine sulphate in ordinary doses gives an increase in tone, an increase in the amplitude of peristaltic waves. Large doses stop peristalsis and decrease the tone, but segmentation movements are little affected and may be somewhat increased. The duration of the effect of an average dose of morphine on the intestine is about six hours. This is true for both animals and man."

Hiccough (*hiccup*) occurs most frequently in cases in which the abdominal viscera and their peritoneal coverings are involved, and in cases of brain and spinal cord lesions.[212] It is fairly frequent after operations on the gallbladder and stomach and is more common in men than in women.[213] Usually the most satisfactory treatment is gastric lavage or Wangensteen suction, although in cases of severe hiccough alcohol injection of the phrenic nerve has been used. Ghose[214] treated successfully a patient with persistent hiccough by injections of 0.5 per cent novocain in the phrenic nerve. The various surgical procedures upon the phrenic nerve are described by Weeks.[215]

Efficient administration of 5 per cent carbon dioxide by means of a mask brings some relief to all patients with hiccough. The condition is controlled or cured in 50 to 60 per cent of cases in forty-eight hours. Hamilton Bailey[216] says that if this method does not produce improvement in thirty-six hours, novocain injection of the left phrenic nerve should be carried out. Golden[217] describes a simple method which he has found effective. An ordinary paper bag of medium size and strength, such as is used by shopkeepers, is placed over the patient's face and held so that it tightly encloses the mouth and nose. The patient is instructed to breathe into the bag. As the available oxygen in the bag is replaced, the exhaled carbon dioxide accumulates, so that in several minutes the saturation of carbon dioxide is enough to produce a therapeutic effect. Six patients were treated by this method. In 1 case the hiccough had been continuous for two days, had prevented the patient from sleeping and eating and had produced soreness in the abdomen and chest muscles. Rebreathing by this simple method checked the hiccough in four minutes, and the patient was relieved of his symptoms without relapse. The other 4 patients had had hiccough of shorter duration. All but 1 were relieved in from three to six minutes. One had recurrences in several hours, which he relieved at home easily by the same method. Hess[218] has had 100 per cent success in the treatment of hiccough by giving the patient a spoon or tongue depressor (or having him use his finger) with which to pull the base of the tongue sharply forward. He says the hiccough will stop in five minutes and not recur.

Backache.—During the operation if the back is protected by placing a small pillow under it the postoperative backache will be much lessened. After operation an electric pad is very useful.

Gas Pains.—Postoperative gas pains are greatly minimized by gentle handling of the intestines during the operation and by the omission of the preoperative purge. After operation attention to fluid and protein requirements and the use of gastric or duodenal suction will usually take care of the situation. A rectal tube is often helpful. Coller[219] says: "As far as I know, enemas do nothing but exhaust the patient, stimulate reverse peristalsis and increase distention, and the rectal tube does nothing but cause piles."

Pain.—For immediate postoperative pain there is no better drug than morphine. One sixth to ¼ of a grain of the sulfate may be given hypodermically everyfour to six hours for two or three doses. In many individuals there is a distinct increase in nausea following the use of morphine, and the patient would rather endure the pain than use the drug. In this event, pantopon, ⅓ grain, by hypodermic may be tried. Morphine is more effective than pantopon against pain. Dilaudid ($\frac{1}{32}$ grain) may be less nauseating but may be dangerous because of its respiratory depressant action. Bargen and Jackman[220] believe that "papaverine compound has certain advantages over morphine sulphate in cases in which it is desired to immobilize or put the bowel at rest . . . [Papaverine compound] was introduced commercially under the trade name of 'spasmalgin'; it contains papaverine hydrochloride 0.021 gram, 'pantopon' 0.012 gram, and 'atrinol' 0.001 gram in 1 cubic centimeter of the drug." A very useful combination is a capsule containing 5 grains of aspirin and ½ grain of codeine sulfate or, better, codeine alkaloid. This capsule may be given as often as every four hours. Neuhof[221] recommends the administration of morphine by means of a slow intravenous saline injection. The dose for adults is $\frac{1}{16}$ grain of morphine per hour in 100 cc. of saline solution. The solution is prepared by adding 2.5 cc. (⅝ grain) of a standard morphine solution to 1000 cc. of normal saline solution. As much as 150 cc. of this solution ($\frac{1}{10}$ grain) may be given per hour if necessary. This may be continued for twenty-four to thirty-six hours. "Demerol" has been used as a substitute for morphine.[222] Macht[223] discusses the use of cobra venom for the relief of pain. Three or 4 Gm. of calcium gluconate three times a day is very helpful for pain due to carcinomatous bone metastases (Brunschwig).

Postoperative Pulmonary Complications.—Rhoads and Ravdin[224] have found that the use of sulfonamide drugs has reduced the mortality of postoperative bronchopneumonia from 69 per cent to 9 per cent. Coller and Singleton[225] ably discuss postoperative pulmonary complications as follows:

[illegible]

great value. In our clinic routine micro-*x*-ray films of the chest on all patients are made and seem worth while as they have revealed many unsuspected lesions. If time allows, the teeth

[illegible]

raise the sputum. Elderly patients should be kept ambulatory as much as possible befor operation. Adequate treatment of patients with asthma, bronchiectasis and cardiac insuffi ciency is especially important.

"The anesthetic used and the method of administration should be such that the patien is able to respond soon after the operation is over. Avertin, which is such a good basa anesthetic, should never be given in such amounts which might cause the patient to slee for long hours after operation.

"The stomach should be empty before general anesthesia. If vomitus should be aspirate during operation, the patient should be bronchoscoped on the spot and the material re moved. At the conclusion of the operation, the pharynx and trachea must be dry and, i secretions are present, they must be removed by catheter suction or by bronchoscopi aspiration. If the operation is such that there is danger of material getting down into th tracheobronchial tree, intubation anesthesia should be used. Burford believes that pneu monitis is as common after spinal as after inhalation anesthesia, but Ferguson finds fewe pulmonary complications when spinal anesthesia is used.

"After operation, the patient should be encouraged to cough often with the abdome supported to lessen pain and strain on the operative wound. He should likewise attempt t breathe deeply at frequent intervals. Since pain from the incision after abdominal opera tions causes a 59 per cent depression of vital capacity by a reflex inhibition of respiration Zollinger has recommended blocking the fifth to the eleventh intercostal nerves with eucupi solution in oil. He found that this decreases pain and increases the vital capacity. The us of transverse incisions in the upper abdomen also makes breathing easier. The inhalation of a mixture of 15 per cent carbon dioxide and 85 per cent oxygen or rebreathing air int a paper bag, will stimulate deep breathing. The frequent turning of the patient from sid to side will increase aeration and promote dependent drainage of the upper lung. Th Trendelenburg positio

bronchi and should b

is active and efficient.

ations containing menthol and benzoin will aid in expectoration, and expectorants such a ammonium chloride and ipecac will thin the secretions and make them easier to raise.

"The early discovery and treatment of atelectasis before pneumonia can develop is im portant. Repeated examinations of the chest should be made for several days after the opera tion. If atelectasis is discovered and deep breathing with coughing can neither expand th lung nor expel the profuse excretions, a soft rubber catheter may be introduced into th trachea by way of the nostril and an attempt made thus to aspirate the secretions. The righ and left main stem bronchi may be aspirated at will by using the maneuver of Haight, tha is by turning the head sharply to one side, the catheter enters the main bronchus on th other side. Application of a local anesthetic to the pharynx is sometimes necessary. If no relieved by these procedures, the patient should be bronchoscoped and the obstruction removed under direct inspection. . . .

"If pneumonia intervenes, it is treated like any other pneumonitis with chemotherapy

after abdominal operations; (2) time of onset—twenty-four to forty-eigh hours after operation; (3) sudden rate of development and severity of symptoms; (4) shif of heart and mediastinum on physical and *x*-ray examination, and (5) bronchoscopic finding of bronchial obstruction."

The use of atropine preoperatively is deprecated by Alexander and by Adams. In th treatment Adams[226] includes hyperventilation by "the use of 95 per cent oxygen and 5 per cent carbon dioxide mixture . . . administered

obstruction with subsequent atelectasis.

Grandstaff[229] says regarding the treatment of postoperative pulmonary collapse: "A new treatment consisting merely in cocainizing the throat with 5 to 10 per cent cocaine solution has been used in a number of cases, with spectacular results and almost instant cure in many cases. The cocaine solution in a cotton ball held in a curved applicator is placed far back

giving suppprt to the abdomen. This relaxing effect from the cocaine is thought to be the essential part of the procedure."

Sleeplessness.—Where sleeplessness does not arise from pain, elixir of triple bromides, phenobarbital (luminal), seconal and nembutal are useful.

Thrombosis and Embolism.—(See the section on Thrombophlebitis and Phlebothrombosis, including discussion of ligation of the femoral vein.)—

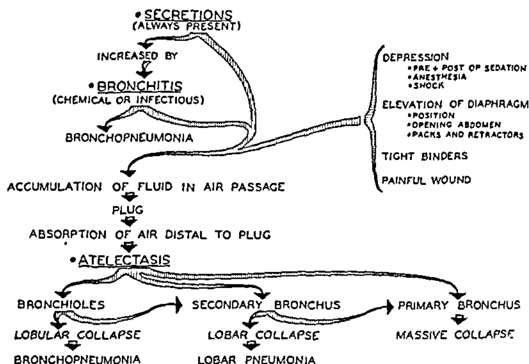


Fig. 581.—Diagram showing probable course of events in the development of bronchial or bronchiolar obstruction with subsequent atelectasis (Eversole, U. H.: S. Clin. North America 24: 515, 1944.)

Thrombophlebitis is an occasional postoperative complication which is chiefly to be feared because of the possibility of embolism.

Priestley and Barker[230] say:

"Pulmonary embolism in our experience is responsible for approximately 6 per cent of deaths which occur after major surgical procedures. A number of factors influence the

Important factors in the etiology of postoperative thrombosis are hemoconcentration, slowing of the venous return,[231] meteorologic influences,[232] perivascular inflammation[233] and accidental injury.

Barker and his colleagues[234] say that venous thrombosis and pulmonary embolism "are more common following types of laparotomy in which operations on the female pelvic organs are done, in which there may be injury to or ligation of branches of the iliac veins, that they are more common in operations of long duration and of great magnitude, in which considerable tissue is removed and in which there is likely to be a greater amount of tissue injury, and that they are more common in patients with carcinoma and in conditions in which there is infection. . . . Postoperative venous thrombosis occurs in episodes and there may be only one episode. If this occurs in a small vein, part or all of the thrombus may detach soon after its formation to become a small (nonfatal) embolus. If it is not detached or if only part of it is detached, the clinical signs and symptoms of thrombophlebitis develop in the involved vein. A second episode may occur in which the thrombosis propagates into a larger more proximal vein and this episode may be characterized by detachment (a larger or fatal embolus), by the development of thrombophlebitis in this vein, or by a small nonfatal embolus and thrombophlebitis. If the first episode of thrombosis occurs in a large vein such as the iliofemoral, the first and only signs of its occurrence may be a sudden fatal embolism, iliofemoral thrombophlebitis may develop which can be recognized clinically, or a small fragment of the thrombus may be detached to form an embolus and iliofemoral thrombophlebitis may develop. Thrombosis may occur in both legs simultaneously or episodes may occur first in one leg and later in the other or in veins in other parts of the body. At the onset of any episode of thrombosis embolism may occur. After thrombophlebitis has developed and existed for more than three or four days, the thrombus does not detach to form an embolus; but embolism may occur if a new thrombus forms in a proximal vein or in a vein elsewhere in the body."

Counseller and McKinnon[235] found that the incidence of thrombophlebitis is roughly ten times higher among gynecologic patients who have varicose veins than it is among patients who are considered to be "excellent risks."

[illegible]
sw [illegible]
ex [illegible]
He says:

"A small rise in the evening temperature, a persistently elevated pulse rate without any detectable cause should cause one to look around after the fourth to fifth postoperative day for other signs and symptoms of latent thrombosis. These are: (1) [illegible]

[illegible] and (5) pain in the small of the back. The three last symptoms are suggestive of pelvic thrombosis, while the location of pressure pain often denotes the site of the original thrombus which, if it remains localized, may not progress to a manifest thrombosis." Unfortunately there are cases of postoperative thrombosis resulting in fatal pulmonary emboli in which there are no premonitory symptoms.

In the prophylactic treatment of postoperative thrombosis, elevation of the foot of the bed 8 to 10 inches (Trendelenburg position) is important.[236] An unconscious patient should have his extremities moved every three to five minutes by a nurse until conscious, and then he should be encouraged to move them himself. McClure's[237] patients have "massage of the body, arms and legs immediately on return from the operating room." Systematic exercise of the arms and legs was advised by Pool[238] in 1913. Exercises with bicycle pedals are recommended by Gamble[239] and by de Takáts and Jesser.[236] Elastic compressive bandages have been recommended[240] Deep breathing and leg exercises are advocated by Potts and Smith.[241]

De Takáts[242] says: "When the origin of the clot is not in saphenous veins but in the muscle veins of the calf, the danger of embolism is much greater and requires a different

type of treatment. Homans called attention to a treacherous, often unrecognized site of thrombosis in the deep veins of the lower part of the leg, involving the posterior tibial, anterior tibial or peroneal veins. . . . If following elevation, bed rest and exercising the muscles in bed, the symptoms wholly disappear, the patient is allowed to get up with an elastic support. But should swelling and cyanosis and especially pain on dorsiflexion of the foot reappear after resuming normal active life, no time should be lost in dividing the femoral vein below the profunda." In speaking of thrombosis of the veins of the calf muscles Sears[243] says: "The onset is usually mild and insidious. The patient sometimes complains of pain in the calf or heel. The duration and intensity of the pain vary. In most patients it lasts from two to eight days. It may disappear after several days, only to be followed by embolism or pain in the femoral region signifying extension to the femoral or iliac vein. There is tenderness on deep palpation of the calf muscles. Forceful dorsiflexion of the foot causes pain in the calf or popliteal area." Sears always divides and ligates the femoral vein when a diagnosis of this type of thrombosis has been made. (See the section on ligation of the femoral vein.) In cases of postoperative saphenous thrombophlebitis Stone[244] ligates the saphenous vein under local anesthesia 1 or 2 inches below the entrance to the femoral vein.

Employment of *anticoagulant therapy* with heparin or dicumarol (dicoumarin) has attracted attention.[245] In a thoughtful collective review Pfeiffer and Sain[246] summarize the most important clinical conditions to which anticoagulant prophylaxis and therapy have been applied as follows: "1. Prophylaxis: (a) After operations that are more commonly followed by thrombosis and embolism: splenectomy, malignancy, pelvic operation and hernia. (b) Prevention of peritoneal adhesions. 2. Surgery of the blood vessels: (a) Traumatic injuries. (b) Thrombosis and embolism—surgical removal. 3. Therapy: (a) Vessels of the extremities: phlebitis and thrombophlebitis, phlebothrombosis and phlegmasia alba dolens. (b) Pulmonary vessels. (c) Central retinal vein. (d) Coronary vessels. (e) Mesenteric vessels. (f) Cerebral vessels. 4. Blood transfusions. 5. Laboratory work." Barker and Priestley[247] feel that "heparin or dicoumarin is indicated for all patients who have had pulmonary embolism or pulmonary infarction and have survived. It is also indicated for patients in whom thrombophlebitis develops, because in these two groups the risk of further episodes of venous thrombosis and/or embolism and even fatal pulmonary embolism is sufficiently great to warrant great concern. We also found that heparin and dicoumarin should be administered postoperatively as a preventive measure to those patients who have had thrombophlebitis recently or pulmonary embolism arising from any cause within six months prior to the operation."

Barker *et al*,[248] say: "Dicumarol has been given to 1000 patients for the purpose of preventing postoperative venous thrombosis, pulmonary embolism, and thrombophlebitis. We have found it effective in preventing these complications in cases in which there has been nonfatal pulmonary embolism, thrombophlebitis or a history of previous thrombosis or embolism, and when the drug has been given prophylactically when no thrombosis or embolism has occurred. There is a small risk of bleeding. This can be further minimized

thromboplastins of constant potency or on the checking of each new batch of thromboplastin with various dilutions of normal plasma. During the administration of dicumarol the prothrombin should be kept between 10 and 30 per cent of normal. Excessive prothrom-

* "Hykinone" (Abbott Laboratories).

doses

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when its effect can be determined by repeated calculations of the prothrombin time. The response of the prothrombin time of different patients is variable. In general, larger doses produce greater prolongation of prothrombin time than do smaller ones, and the effect endures longer. A plan of administering 300 mg. on the first day, 200 mg. on the second day and 200 mg. on each day after the second on which the prothrombin time is less than 35 seconds has been used by us. After administration of the first dose from twenty-four to forty-eight hours elapse before an effect on prothrombin time is noted. After discontinuation of administration, prothrombin time may be prolonged from two days to two or three weeks, depending on the amount given. . . . The danger of hemorrhage from administration of dicoumarin serves as a constant emphasis for care in its use."[250]

de Takáts[251] says: "Fear, apprehension, nervous strain and hemorrhage increase the tendency to clotting; prostigmine, a drug frequently used as postoperative medication, by its cholinergic action lessens the postoperative tendency to thrombosis." de Takáts and his associates[252] believe that digitalis favors the tendency to thrombosis.[253]

Attacks of *pulmonary embolism* may be mild or fatal. Barnes[254] says: "In the past, too much emphasis has been placed on sudden cyanosis and dyspnea as cardinal signs of pulmonary embolism. A common picture of pulmonary embolism is that of shock, with or without dyspnea, with faintness, pallor, sweating, a marked fall of blood pressure, tachycardia, vomiting and sometimes collapse. Not only may the classic symptoms of pulmonary embolism be lacking but the triad of diagnostic observations, that is, bloody sputum, pleural friction rub and signs of pulmonary consolidation, may not be present for 24 hours after the onset and they may never be present in some cases." The treatment of pulmonary embolism includes the administration of oxygen (preferably 100 per cent by means of the Boothby mask), papaverine, $\frac{1}{2}$ grain intravenously,* and atropine, $\frac{1}{60}$ to $\frac{1}{70}$ grain intravenously. Pulmonary embolectomy has been done successfully in 9 out of 132 attempts. (de Takáts[242]) Priestley and Barker[230] say: "Proper use of heparin in all cases in which evidence of nonfatal pulmonary embolism is available should prevent about one-third of the deaths which now occur from postoperative pulmonary embolism." (*See the important section on ligation of the femoral vein in the prophylactic treatment of pulmonary embolism.*)[254a]

Murray[255] says: "When pulmonary embolism has

Anxiety.—This definite entity deserves the surgeon's careful attention. Calm reassurance and a little intelligent psychotherapy will do wonders.

Psychoses.—Volkmann[256] says that the incidence of postoperative psychoses is about 0.2 per cent. It is more common in males than in females. The treatment is symptomatic.

* de Takáts (J. A. M. A. 114: 1415, 1940), in recommending papaverine, says that it should be freshly prepared from the powder.

Retention of urine in the bladder is a very common complication of operations. (See the sections on Retention of Urine in the chapters on the male and female genitourinary organs.) Warm fomentations to the perineum and bladder region, permitting the patient to hear the sound of running water, enemas and, even after an appendectomy with a muscle-splitting incision, permitting the patient to stand beside the bed may be of assistance. Woodruff and TeLinde[257] have reduced the incidence of catheterization after pelvic laparotomies from 51 to 6.5 per cent by instillation in the bladder of 1 ounce of 0.5 per cent aqueous solution of mercurochrome in the operating room. Prostigmine (prostigmin methylsulfate, 1:2000 solution, 1 cc.) has been recommended.

Gordon[258] conducted a comparative study on postoperative dysuria in two series of surgical cases: 318 patients who received no prostigmine (controls) and 85 patients, 50 of whom were given prostigmine preventively and 35 of whom received the drug as corrective therapy. The most satisfactory results were obtained by the preventive use of the drug. Dysuria developed in only 3 cases, 6 per cent of the 50 cases, and catheterization was required in only 2 cases, or 4 per cent. Dysuria developed in 27.6 per cent of the controls. The time interval between operation and spontaneous urination was reduced by more than half—from 23.5 hours to 10 hours—through the use of prostigmine. Ewert and Hoffman[259] recommend the use of prostigmine, 0.5 mg. (1/130 gr.) or 1 cc. of a 1:4000 solution, and morphine, $\frac{1}{4}$ gr., and catheterization every six hours until the residual urine is 60 cc. or less. Two ounces of 0.5 per cent aqueous mercurochrome are instilled after each catheterization.

Webb[260] has given the following instructions for patients with postoperative retention of urine on his surgical service. "As soon as postoperative retention of urine is reported the usual methods of treatment should be applied. If the patient does not void promptly the following treatment is to be applied: Insert a catheter in the usual manner and withdraw from 25 to 75 cc. of urine from the distended bladder and then inject between 15 *and 20 cc. of 20 per cent borated glycerin through the catheter into the bladder.* Withdraw the catheter. Micturition will occur in from ten minutes to one hour in over 80 per cent of the cases and retention will not recur. The borated glycerine acts on the intraparietal vesical ganglia. *Warning: Borated glycerin must not be injected into an empty bladder. Follow* [illegible]

by mouth every half hour for eight doses." Reimer[262] gives a tablespoonful of 20:3000 solution of liquor potassii acetatis once an hour or every half hour if necessary. Water sprayed from a needle on to the glans penis is recommended by Bennett[263] to induce urination

If the patient fails to urinate after a short trial, catheterization should be carried out promptly. (See the section on catheterization.)

The author believes with Cabot that the cause of cystitis is failure to use the catheter rather than infection by its use. It is generally desirable now to *administer orally 0.5 Gm. of sulfadiazine with 1.0 Gm. of sodium bicarbonate three times daily to every patient who requires catheterization.*

Cabot[264] says that the management of postoperative urinary retention is based on the following "accepted knowledge": "(1) The introduction of bacteria into the healthy bladder [illegible]

the bladder, they will undoubtedly frequently catheterize bladders with lesser amounts, [illegible] the other horn of the dilemma which permits or may permit distention beyond [illegible] zation [illegible] period

[illegible] nd we [illegible] on was [illegible] wholly faulty. This dogma grew up in the days when distention of the bladder was regularly allowed to occur. Catheterization was then undertaken for an overdistended bladder, and definite reaction of that bladder by congestion, edema, and even microscopic hemorrhage regularly occurred. This led to a condition likely to continue the retention, and from this, I think, [illegible]

[illegible] repeated more than once or twice, the catheter should be tied [illegible]

[illegible] sterile equipment is used or when the catheter is irrigated by hand by any but the most skilled assistants." Moore and his colleagues[266] say: "It has been ascertained that overdistention of the bladder predisposes to inefficient vesical function evidenced by the presence of residual urine after the act of micturition has been resumed. It is not uncommon to find 500 to 1000 c.c. of residual urine after the patient has voided 300 to 500 c.c. It is highly important that the amount of residual urine be checked daily and the bladder drained completely by catheter at least every twenty-four hours, until none is found, as in so doing, the fundamental cause of infection of the bladder and so-called postoperative cystitis is avoided. If these measures are not employed, urinary infection of an intractable type may be a late and distressing sequel. In our experience, the judicious use of a catheter has been the means of preventing postoperative urinary infection whereas the avoidance of catheterization means failure to recognize the presence of residual urine and infection." For a neurogenic bladder, Voris and Landes[267] recommend an indwelling or suprapubic catheter.[268] *When an indwelling catheter is used, it is wise to give the patient orally 0.5 Gm. of* sulfadiazine three times a day as a prophylaxis against infection.[269]

Cystitis.—Cystitis as a postoperative complication can usually be avoided by intelligent catheterization, as described previously. Should cystitis develop, as evidenced by an elevation of temperature, by an excessive number of leukocytes in the urine and possibly by painful urination, it is particularly important not to permit the bladder to become overdistended. An indwelling (Foley) catheter is usually employed, with periodic irrigations of the bladder with warm saline, potassium permanganate or boric acid solution, leaving in 1 or 2 ounces of 10 to 25 per cent argyrol.[270] Sulfadiazine, 1.5 to 3 Gm., should be given daily by mouth in divided doses for six days.[269] It is important to keep the urine alkaline (pH of 7.5 or more; see the following section). Other urinary antiseptics are mandelic acid (in acid urine; pH 6 or less); mandelamine; methenamine (urotropin) in doses of 2 to 3 Gm. in twenty-four hours accompanied by an equal dose of acid sodium phosphate given separately to insure an acid urine; sulfanilamide,[271] and sulfathiazole,[272] 0.5 Gm. four times a day.[273] Helmholz[274] believes that "streptomycin should prove to be the most useful urinary antiseptic so far developed."[275] For a discussion

of the care of the urinary tract after abdominoperineal resection of the rectum, see the recent article by Jones.[273]

Anuria (Suppression of Urine).—Failure of the kidneys to secrete urine is an extremely serious complication. The diagnosis is made by failure to obtain urine on catheterization. Mayo and Schlicke[276] have given the following valuable advice in regard to anuria:

> At the first signs of diminishing urinary flow—and these signs unfortunately are frequently overlooked or attributed to improper charting—prompt action is required. After simple retention of urine has been ruled out by catheterization of the bladder, the most important factor is to find the cause. Since dehydration is usually the paramount factor, this should be remedied without delay. Aqueous solutions of glucose afford the most readily available sources of water for renal excretion, particularly if hypertonic solutions are used. Aminophylline is a valuable stimulant to a sluggish kidney. Studies of the blood chemistry should be carried out to determine the degree of nitrogen retention present and the extent of disturbance of the acid-base equilibrium. Acidosis or alkalosis should be corrected. A plain roentgenogram of the abdomen will reveal the presence of opaque calculi. A careful physical examination should be carried out to detect the presence of associated conditions. If routine measures do not restore urinary flow, cystoscopic examination should be carried out without delay. Ureteral obstruction usually can be relieved by catheterization, but if the obstruction is bilateral and impassable, nephrostomy must be performed. A stormy course with pain suggests an obstructive type of anuria A history of chemotherapy is important. Many of the measures often employed are of doubtful value. Sweating and purging exhaust the patient, further deplete the body of fluid and electrolytes, and fail to eliminate nitrogenous waste. Heat applied to the renal areas finds its greatest usefulness in the comfort which it may afford the patient.

It is known that sulfonamides have caused anuria, crystals and calculi formed by them having been obtained by ureteral lavage in suspected sulfonamide anuria.[277] Sulfadiazine, sulfathiazole and sulfapyridine are 500 times more soluble in alkaline (pH of 7.5 or more) urine than in acid (pH of 7.0 or less) urine.[278] Swartz and his colleagues[279] found that after sulfathiazole administration, 7.6 per cent of alkaline urines and 92.4 per cent of acid urines showed crystals; after sulfadiazine, 8 per cent of alkaline urines and 92.0 per cent of acid urines showed crystals.

It is important, therefore, whenever sulfonamides are administered, to maintain an alkaline urine (pH of 7.5 or higher) in order to avoid oliguria and anuria. By means of nitrazine paper, nurses should make pH determinations on all urine during sulfonamide treatment.* The reading is made by means of a color chart and should be recorded in the nurses' notes. Examination in the laboratory is more accurate. Sodium bicarbonate is given by mouth if the urine is found to be acid. Gilligan and his associates[280] say that 13.7 to 19.5 Gm. of sodium bicarbonate orally in six doses will produce alkaline urine and will not cause alkalosis. Sodium citrate in citrous juice is useful. Alkaline solutions are given intravenously when alkalies cannot be given orally. These must be given in quantity sufficient to produce alkaline urine. For this purpose the following are recommended: (a) one-sixth molar sodium R-lactate (isotonic: 1.866 Gm. of sodium R-lactate to 100 cc.) and (b) lactate Ringer's solution (Hartmann's solution; 1000 cc. contains 5 or 10 Gm. of dextrose, 0.6 Gm. of sodium chloride, 0.31 Gm. of sodium R-lactate, 0.03 Gm. of potassium chloride, 0.02 Gm. of calcium chloride).[281] Rohr and Christopher[282] found that 1,000 cc. of one-sixth molar sodium r-lactate maintained urinary alkalinity "for an average of twenty-four hours" and that

* Phenaphthazine paper (Squibb).

"at least 24 Gm. per day of sodium bicarbonate was necessary to maintain urinary alkalinity after the intravenous administration of fluids was discontinued." After clinical studies Penna and Christopher[283] reached the following conclusions:

> "1. Adults can be given sterile solutions of 7.5 Gm. of sodium bicarbonate in 100 cc. of water intravenously without ill effect. 2. Fifteen Gm. of sodium bicarbonate daily (given intravenously in two doses each of 7.5 Gm. in 100 cc. of water twelve hours apart) will keep the urine sufficiently alkaline to prevent sulfadiazine crystalluria in the average adult. 3. If 7.5 per cent solution of sodium bicarbonate is given intravenously, the same degree of alkalization can be obtained with one-fifth the volume of solution as is necessary when sixth molar sodium r lactate is used. 4. The urine can be made alkaline within thirty [illegible] [illegible] urine alkaline."[284]

Root and Hanson[285] report a very interesting case of a boy of 5 years with postoperative anuria of ninety-seven hours' duration which they attributed to loss of chlorides incident to continuous vomiting. There was grave nitrogen retention. The anuria was relieved almost immediately following the intravenous injection of 60 cc. of a 10 per cent solution of sodium chloride.

Wound Disruption.—Hesseltine and Bohlender[286] estimate that there are 15,000 wound disruptions in the United States annually and that as a result 1,000 to 2,500 patients die. The average mortality is said to be about 35 per cent.[287] Norris[288] found that most disruptions were upper abdominal, while Bettman and Lichtenstein[289] found that most of them were lower abdominal. Many etiologic factors are concerned in wound disruption. Wound infection, improper suturing, inadequate closure of the peritoneum,[290] improper incisions, postoperative distention, vomiting, coughing, vitamin C deficiency,[291] hypoproteinemia,[292] allergy[293] and disintegration of catgut,[294] all play a part, and many of them are preventable. Pickrell and Clay [295] do not believe that catgut allergy plays a part in wound disruption. Factors thought to be useful in the prevention of wound disruption are as follows: greater use of transverse incisions,[296] retraction of the rectus and preservation of its posterior sheath,[297] use of buried wire sutures,[298] wire stay sutures[299] or silk rather than catgut and catgut employed with the care afforded silk.[300]

Immediately after wound rupture Eliason and McLaughlin[301] recommend the following treatment which they say was advocated by Clute.[302] "The wound edges and the protruding viscera are first painted with 2 per cent aqueous mercurochrome. The omentum and gut are then gently replaced down to the level of the parietal peritoneum." Gauze packing is inserted, the skin edges are approximated with flamed adhesive tape and a firm dressing is applied. Application of compound tincture of benzoin to the skin will make the adhesive plaster adhere better. The wound is undisturbed for five days, when the packing is replaced if necessary. Colp[303] gradually removes this packing as the wound heals. Immediate secondary suture in the operating room is generally less desirable than the foregoing method. If secondary closure is done in the operating room, closure with through and through sutures, rather than by layers, is advisable. In making a plea for the conservative treatment of wound disruptions, Fallis[304] says: "Seven of the sixteen patients whose wounds were resutured died, a mortality of 43 per cent, but

only three of the eleven patients whose wounds were treated by adhesive strapping died, a mortality of only 27.3 per cent."

Fecal Impaction. (See section on fecal impaction.)—Occasionally when there has been no bowel movement for a number of days or a week or more, despite vigorous enemas, the patient will be unable to expel the fecal mass. This is particularly likely to occur in patients who come to the operating table in a constipated condition. When this condition is suspected, the gloved and well lubricated finger is inserted into the rectum, and if fecal impaction is encountered, it is broken up. Occasionally it will be possible to extract the hard masses digitally.

Wound Infection.[305]—If local tenderness or increase in the temperature and in the leukocyte count makes one suspicious of wound infection, the wound should be inspected. If there is redness or swelling, a few sutures are removed, and warm boric acid or saline compresses are applied. A culture should be made as soon as pus appears. A wound may show a painful red swelling as late as two or three weeks after the operation. Such a swelling may discharge itself spontaneously, or it may require incision and drainage to evacuate a few drops of pus and generally a catgut ligature knot. This is particularly likely to happen if knots of absorbable material are placed too near the skin surface. For wide-open wounds with extensive infection the local treatment will usually consist of using sulfonamides or penicillin in carbowax, boric acid or saline solution dressings or the Carrel-Dakin treatment. (See the section on the Carrel-Dakin treatment.)

Meleney[306] greatly reduced his incidence of wound infections by substituting silk for catgut in "clean cases," such as thyroid and hernia operations and open reductions. He stresses the importance of properly and completely masking the nose.

Shambaugh[307] found that "in a controlled series the incidence of suppurative wound infection where catgut was employed as suture material was twice as great as where silk was used. Where fine silk (No. 4) is used and the principles laid down by Halsted are followed, the presence of silk in suppurating wounds does not, on the average, delay the healing of the wound. Infected wounds may heal completely and permanently without discharging the silk sutures. The presence of fine silk in infected wounds may delay healing for periods up to 3 or 4 months, but this is exceptional and should not deter one from employing the silk technique in suitable cases "

The *sulfonamides* have come to play an important part in the field of postoperative infec-

[illegible]

traumatic wounds, compound fractures, appendectomies, bowel resections, pulmonary lobectomies, nephrectomies and transurethral prostatic resections. In view of the frequency with which subacute bacterial endocarditis follows the extraction of septic teeth, or the removal of infected tonsils, it has been our practice to give sulfadiazine to all patients with acquired or congenital heart disease in whom these operative procedures are contemplated. Patients with chronic pulmonary disturbances, such as bronchitis and bronchiectasis, often develop severe pulmonary infection after operation and, in such cases, it seems advisable to administer the drug as a preventive measure. Furthermore, it is well to give the drug in patients requiring catheterization and cystoscopic examinations to prevent the development of infection."

... swelling and tenderness develop around a wound, it is well

... d[309] say:

... urine output of about 1000 cc., a sufficient and ... be maintained with an initial dose of 0.1 gm. ... the same dose in twenty-four hours divided ... hours. It is usually convenient to make the ...

This may then be maintained by lower doses because of the slower ...

"When sulfanilamide is deposited on exposed tissues as a *powder*, it is found to be readily soluble in the tissue fluids and may reach the concentration of 1500 mg. per 100 cc. of blood. It is readily absorbed and *is all gone in two or three days*. Sulfathiazole and sulfadiazine are much less soluble in local fluids, reaching a level of not more than 100 mg. per 100 cc. ... much more slowly absorbed. The latter drugs tend to produce more ...

... d and sulfonamide admin- ...

"In case of septicemia, it is best to obtain concentrations of free drug in the blood of 12 to 20 mg. per 100 cc. In using sulfanilamide, the desired concentration of drug in the blood can usually be obtained and maintained by an initial oral dose of 4 to 5 gm., followed by doses of 1 to 1.3 gm. every four hours day and night until convalescence is established. The above dose schedule applies also to the subcutaneous administration of sulfanilamide in an 0.8 per cent solution by the subcutaneous route, although the rate of absorption by the tissues will influence the number of injections necessary. When sulfathiazole or sulfadiazine is employed, the usual dosage by mouth is 4 gm., followed by 1 gm. every four hours. As a rule, in order to obtain the necessary concentrations in the blood which are desired, it is necessary to administer the initial dose of drug by vein. In those cases in whom intravenous therapy is necessary throughout the course of treatment, repeated 2-gm. doses must be made at six- to ten-hour intervals. The above schedule of dosage should be continued for at least seven days and in most instances this will be sufficient, although such factors as outlined previously will influence the total amount of drug necessary for complete cure."[310]

Postoperative Hemorrhage.—If the bleeding is at an accessible place, very slight pressure will control it. If the bleeding is inaccessible, the wound should be reopened and the bleeding point ligated or packed. If hemostatic serum is employed it is of the utmost importance first to question the patient or his family as to the possibility of sensitivity to horse serum.

Postoperative Parotitis.—Madding and Fricke[311] say:

"The clinical picture of secondary parotitis usually is clear-cut and the diagnosis is made easily. Onset occurs most often between the first and fifth postoperative days, but it may occur at any time. It is associated with fever, swelling over the parotid gland, and in all cases some degree of discomfort which is most marked on opening and closing of the jaw. On examination, the orifice of Stenson's duct usually is visibly inflamed. Besides the redness and swelling about the orifice, turbid saliva or pus may be expressed by gently massaging along the course of the duct. This is not necessary to make the diagnosis and is a practice which probably should be condemned because of the added discomfort to the patient. Rarely is the seventh cranial nerve involved and then only when suppuration is present."

In the past the mortality was believed to be in the neighborhood of 50 per cent. However, in a series of 190 cases of postoperative parotitis, Madding and Fricke found only 1 death which could be attributed directly to the parotitis. Preoperative and postoperative prophylaxis include hydration, oral hygiene and early institution of active mastication.[312] As soon as the diagnosis

is made roentgen therapy should be started.[313] Radium therapy[314] and use of Lugol's solution[315] have been recommended. Sulfathiazole should be given.[316] Incision and drainage is usually not required.

Brachial Plexus Paralysis.—In reporting 9 cases of postoperative paralysis of the brachial plexus Clausen[317] emphasizes the following points in its prevention:

> "With the patient in the Trendelenburg position and the shoulder depressed, the arm should be left at the patient's side. When the arm is abducted, the head and neck must be held in neutral position or adducted. The arm should never be abducted beyond 90 degrees under any circumstances. The arms must not be abducted and extended above the head when the patient is in the supine or the prone position. Shoulder braces must be adjusted before the Trendelenburg position is assumed; they should be well padded and adjustable in height as well as in width. Wide separation of the head and shoulders must be avoided. Movement of an anesthetized patient must be attended by adequate personnel. The possibility of this unfortunate complication must be kept in mind by every member of the operating room staff."

Cerebral Complications (*Cerebral Anoxia*).—Behrend and Riggs[318] believe that most types of postoperative cerebral complications ("anesthetic deaths," hemiplegias, confused states, psychoses, comas and convulsions) may occur as a result of cerebral anoxia. Cerebral anoxia is related to general circulatory insufficiency as affected by organic heart disease, anemias, age, anatomic factors, metabolic disorders, shock, anesthesia and nutritional deficiencies.[319]

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CHAPTER XXV

THE SURGICAL INTERN

A SURGICAL internship presents a twofold opportunity. The surgical intern has an opportunity to observe and to participate in surgical work. He has an opportunity to learn at close hand the surgical methods and the technic of dealing with patients employed by the surgeons who are most respected in the community, and he has the opportunity to gain the approbation of surgeons with whom he may desire to become associated. The intern who most successfully cares for the patients assigned to him and who best serves the interests of his attending surgeons generally will be the most successful in his practice.

GENERAL QUALIFICATIONS AND DUTIES OF THE SURGICAL INTERN

Industry.—An intern must expect to work hard. There is always more work that should be done and can be done than there is time in which to do it. The intern must not only work hard but work efficiently. He must plan work so as to minimize the number of unnecessary trips about the hospital. He should be prompt in taking care of all calls regarding accidents or emergencies which may arise within the hospital, no matter how trivial they may seem to him when reported. He should respond immediately to any urgent call even if he is not on duty at the time or if the call should be taken by some other intern. If unjustly called, he can complain about it afterward. He must never forget that patients often suffer extreme though unnecessary apprehension because of conditions which are relatively innocuous, and it is part of the intern's duty to allay their mental as well as physical suffering. Moreover, occasionally, an apparently unimportant occurrence may be reported to him by a nurse which he may find is of grave seriousness on his arrival. No chances should be taken.

The work is very hard, and the intern should endeavor to obtain a certain amount of rest in his time off. But as Carrington[1] says, "If you think you are overworked, you are a round peg in a square hole, because in private practice you will work harder than ever an intern worked."

Intelligence.—The good surgical intern is intelligent. He grasps quickly what is told him, and he is alert to understand all the procedures which are employed. Those which he does not understand he inquires or reads about.

Tact is essential to the intern. He often will be severely cross questioned by a patient in the absence of the attending doctor, particularly as to the possible prognosis of the ailment. The writer has seen the parents of a child with mild concussion of the brain thrown into the wildest panic by the grudging admission of the intern, in answer to their insistent questions, that occasionally craniotomy may be required in such cases. A terror-stricken woman after radical amputation of the breast was pleasantly informed by a conversationally inclined intern that he knew how she felt "because his mother died of cancer." The writer has seen the professional instinct so transcend the social as to cause one of a group of physicians in consultation at a patient's

bedside to inquire in an all too audible voice, "All these patients die, do they not, doctor?"

Judgment.—Good judgment is inherent in some men; in others it may be acquired by experience; in others it is never acquired. In the absence of the attending surgeon, an intern is often required to make a quick decision. A severe hemorrhage, a burn or severe shock may call upon him for exercise of good judgment. The best way for an intern to acquire this judgment is to anticipate continuously all types of situations which may require his attention.

Personality.—The average intern is perhaps a little overconscious of the recentness with which he has graduated and is hypersensitive to what he thinks may be the inward contemptuous criticism of him by the patient. He may accordingly adopt a rather blustery "know-it-all" manner to cloak his real or supposed deficiencies. It is far better to gain a patient's admiration and confidence by courtesy and modesty and by zealous efforts in behalf of his comfort and health.

The intern must endeavor to have at all times a neat appearance. After he has been up all night, a shave and a fresh suit of clothes will help him rather than be an extra burden.

Loyalty.—The intern should be loyal to the attending surgeon. He is the personal representative of the attending surgeon in the latter's absence and should strive to take care of the patient as conscientiously and as thoughtfully as would the attending surgeon were he present. He may have profound differences of opinion as to the proper conduct of the case, and not infrequently they are just and well grounded. Such differences of opinion can be respectfully taken up with the attending surgeon, often to mutual profit, but they *never* should be confided to the patient or to his nurse.

A surgeon working at high tension in the operating room may be unjustly impatient with an intern. The latter should strive to be patient and self-contained under such circumstances and should try to remedy the situation by greater efforts. He must remember that very soon he will be similarly situated.

The intern should be loyal to the hospital. If he will take pains to familiarize himself with the difficulty and the multiplicity of details in the administration of a hospital,[2] he will become far more sympathetic with its problems. Should a patient unjustly criticize the hospital, the intern will not only help the hospital but also the patient's welfare by endeavoring to explain the real state of affairs, of which the patient may have no knowledge.

The intern will find it greatly to his profit and to the pleasure of his sojourn in the hospital to be uniformly courteous and respectful to nurses. Under no circumstances should he be overly friendly with them. It is generally desirable to address as many nurses as possible by name. Suggestions as to treatment when made in the proper spirit by older, experienced nurses may well be given careful attention. When the intern feels, however, that he is on sure ground, he should maintain his authority and not modify his orders to suit the nurse. An intern should never criticize a nurse in the presence of or within hearing of a patient.

Responsibility.—The intern should never take his relation to his patients lightly. On him lies a heavy responsibility, and the more seriously and conscientiously he accepts that responsibility, the greater will be the responsibility and trust given him.

Integrity.—This of course is a sine qua non. The word of an intern must be absolutely depended upon. Momentous decisions may be involved. The examination of urine by the "sink test" is grounds for dismissal.

Surgical Dressings.—The surgical intern should most carefully perform those dressings which are delegated to him and strive to acquire a good surgical technic. The intern or doctor doing dressings can greatly win the esteem of the patients by his care, gentleness and patience. It is desirable for the intern to do all his dressings as early in the day as possible. Dressings made immediately after an operation should be applied neatly and firmly. Royster[3] advises heaping up the dressing directly over the incision so as to exert pressure and favor clean and prompt healing of the wound. Royster quotes Blair[4] as emphasizing the fact that properly applied pressure is one of the great aids to the natural healing forces and has four advantages, viz., (1) the elimination of dead spaces, (2) the control of oozing, (3) the limitation of venous and lymph stases and (4) limitation of the amount of plastic material that pours into the wound. In dressing an infected wound, the intern should never allow his fingers to become saturated or even contaminated with the purulent discharge from dressings. All manipulations or procedures in a dressing should be done with two sterile hemostats or forceps, one in each hand. Sterile gloves are worn if the wound or any part of the dressing must be touched. If the dressing is fastened by adhesive plaster and the patient is sensitive, it will be well to cut the adhesive plaster at the edge of the dressing, leaving attached to the skin the ends of the plaster. Fresh adhesive plaster may be placed on top of these ends until finally they are all removed at one time. In less sensitive patients the plaster will be removed. The proverbial quick jerk is not always wise, as small portions of the superficial epidermis may be torn off. It is better to pull the skin away from the adhesive plaster as the latter is gently peeled off. It is to be remembered that certain patients are extremely sensitive to adhesive tape. If it is desired to make adhesive tape more adherent, the skin is painted with compound tincture of benzoin before the tape is applied.[5] Sixty per cent carbon tetrachloride and 40 per cent naphtha has been recommended as a solvent for adhesive plaster, but Chandler[6] has reported the near death by asphyxia of a child aged 4 years because carbon tetrachloride was used. The Jacksons[7] recommend oil of wintergreen "applied with a very small cotton swab only at the point of separation of the adhesive from the skin." Benzine or cold cream is also useful. The patient should be reassured that the intern will do everything possible to minimize the pain, and the intern should give ample signs of that caution. *Liquid adhesive* (solutions of certain water-soluble resins) has many uses in attaching dressings to the skin. The liquid adhesive is painted directly on the skin before the dressing is applied.[8]

After the bedcovers have been turned back to expose the dressing and the top dressing has been removed, either by clipping or removing the adhesive plaster or untying the adhesive plaster and tape fasteners, a sterile towel is laid over the bedclothing immediately below the dressing. The edge of this towel next to the dressing is turned under the bedclothing. In removing the dressing next to the skin it is well to peel it off from the bottom upward in a direction that parallels the incision. The nurse assisting at the dressing then places upon the towel the requisites of the dressing, several dry gauze pledgets, several flat sponges and possibly several sponges saturated in alcohol. The

nurse then hands to the doctor two hemostats or tissue forceps. It is better for her to hand these to the doctor rather than to place them upon the sterile towel. In case the latter has been done, however, a hand should be placed under the towel to lift the handle of the forceps upward, so they may be grasped without contaminating the towel. The doctor performs the entire

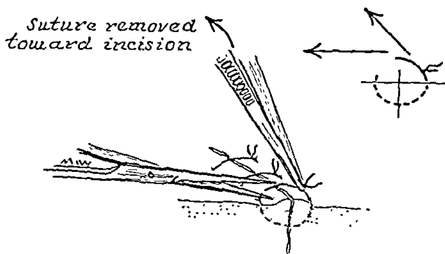


Fig. 582.—Method of removing skin sutures

dressing by means of two instruments and does not touch the skin, wound or dressing with his hands. A little practice with this method, and one will become thoroughly accustomed to it. In many instances a relatively nonadherent dressing such as vaselin gauze will have been applied. Potts[9] finds vaselin gauze objectionable and recommends mosquito netting impregnated

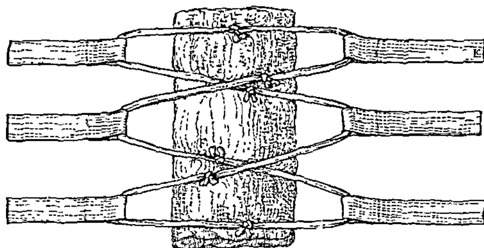


Fig. 583.—Simple method of holding dressing in place with tape-ties.

with 75 per cent paraffin and 25 per cent petrolatum jelly ("paraline"). Nylon surgical gauze* is highly praised by Bingham.[10] By means of the *hemostat* a pledget of gauze saturated in alcohol is passed over the skin all around the wound, and a second pledget is sponged onto the wound. When the *removal of stitches* is indicated all the stitches are thoroughly sponged

* Johnson & Johnson, New Brunswick, N. J., and Huguet Fabrics Corp., Hornell, N. Y.

with alcohol. The central portion or knot of the suture is grasped and clipped with scissors at one side close to the skin entrance. With a quick jerk the stitch is then withdrawn, care being taken to pull it across the midline so as to avoid the danger of opening up the wound by the traction (Fig. 582). Where mattress sutures have been tied over buttons it will be necessary carefully to lift up the button in order to clip the suture beneath it. It is generally wise to remove first those stitches which are liable to occasion the least pain. After the sutures have been removed, if bleeding occurs, it is wise to sponge the wounds made by the stitches until the bleeding has stopped. The entire wound and neighborhood is then again sponged with alcohol. Sterile gauze is placed upon it by means of the hemostat or forceps, and the dressing is fastened in place with adhesive plaster. On the face, or other conspicuous

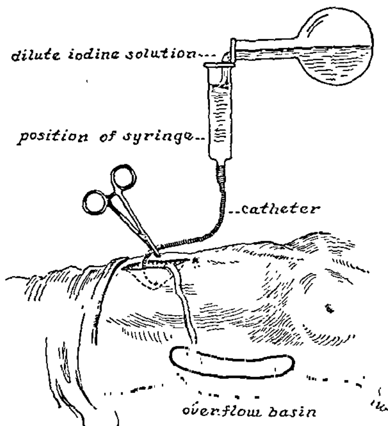


Fig. 584.—Method of irrigating an infected wound.

situations, the healed wound may be painted with collodion at four to five day intervals for several weeks in an effort to diminish or prevent widening of the scar. Howes[11] recommends cellophane instead of gauze as a wound dressing.[12] "Scotch tape" is often useful in place of adhesive tape. When the dressing must be changed frequently it is held in place with "tape-ties." A simple method of making these ties is shown in figure 583. If the wound contains a drain or has a profuse purulent discharge, a somewhat different procedure is followed. The wound and adjacent skin is carefully cleansed with dry and with alcohol-soaked pledgets. If these are too painful in the wound itself, boric acid solution on cotton applicators may be used. The manner of removing clips from the skin is illustrated in figure 14. When there is a very profuse discharge from a deep cavity, it may be well to irrigate it under very low pressure with normal saline solution (Fig. 584).

The *shortening of drains* in the abdominal cavity is a matter requiring considerable skill and judgment. In most cases it is well to shorten the drain $\frac{1}{2}$ to $\frac{3}{4}$ inch daily. Very valuable are the calibrated drains described by Touroff.[13] Where two or three cigaret drains have been used, one cigaret drain is withdrawn entirely eight to twelve hours after operation. When at subsequent dressings it is thought unwise to shorten the drains, it is well to give them a slight twist so as to break up the recent adhesions that have formed. In many cases, intestinal obstruction has been caused by improper management of the drains, and the chief errors which have brought about this condition have been failure to move the drains daily and leaving them in place too long. When a drain is to be removed or shortened the patient is warned that he will experience pain and to brace himself for it. The hands of a child should always be held. When the drain has been shortened, the excess length above the wound should be cut off with scissors. While this is being done the drain at the wound edge should be held firmly by a tissue forceps or hemostat to prevent its accidental withdrawal. The safety pin should then be replaced in the tube to prevent its slipping back into the depths of the wound. With a little practice these safety pins may be put in place by means of the two hemostats without using the hands. When the drains are composed of thin rubber Penrose tubing only, there is some danger of their breaking on being withdrawn, particularly if they have been improperly sterilized. To avoid this difficulty Charnock[14] advises sewing a seam down the center of the drain with a sewing machine before it is placed in the wound.

In cases in which the discharge from the wound is extremely irritating to the skin, as in cases of *gastric or duodenal fistula*, it may be necessary to place in the wound a small rubber tube connected with a continuous suction device so as to prevent any discharge from reaching the skin.[15] For protecting the skin after an enterostomy, McClanahan[16] says that Harvey B. Stone began years ago using an aluminum paste. Its use has extended to many of the Baltimore hospitals, where it has been employed for years with the greatest satisfaction to doctor, nurse and patient.

℞		
℞	Aluminum metal (fine powder)	1 part
	Liquid petrolatum (or olive oil)	q s. to stiff paste
	Zinc oxide ointment	2 parts

Sometimes the preparation is used with less of the metal, the proportions being one part of the metal to three parts of the ointment, and this has proved satisfactory. The paste may be kept in jars and in some hospitals is kept routinely on the dressing carriages. At times it may be advisable to maintain a supply at the bedside. It is well to start applying it before there is irritation, employing it at the time the drainage is expected to commence; *i. e.*, when a colostomy or ileostomy is about to be opened. There is no reason, however, not to apply it to skin already irritated, and indeed in such instances it is appreciated greatly. When there is profuse drainage, it may be necessary to apply it frequently, sometimes with each change of dressing, to insure that the skin is adequately covered. Removal of any soiled excess of the paste may be facilitated with olive oil on gauze or cotton pledgets. Also it has been helpful in cases of profuse biliary discharge in which irritation has been marked. Cunningham[17] has had excellent results in the treatment of abdominal wall excoriation in cases of gastric and intestinal fistulas with copper bronzing powder. His technic is as follows:

"The copper is applied to the skin around the fistula as a dusting powder, being rubbed in thoroughly with the finger or cotton applicator, or a suspension is made up in bronzing liquid, one part of copper being used to about six of the suspending agent. This is painted [illegible] as the sus- [illegible] were tried, [illegible] culous care should be taken not to have any intestinal secretions pent up under the application. When the skin is not excoriated, copper suspension is indicated. *If excoriation is present the powder* is advisable until healing has taken place, following which the suspension is used. In addition, we use the cradle with electric lights, mopping with gauze or syringe siphonage when the secretion is copious, and occasionally the duodenal tube when there is extensive loss of fluid."

Straus[18] prevents skin digestion in cases of high intestinal fistula by coating the skin with a thin film of rubber. This is accomplished by painting the surface with *latex*, the juice of the rubber tree.[19] Presman[20] has recommended the use of a solution of vinylite resin,* 25 Gm.; acetone, 100 cc., and collodion 25 cc. The solution is painted on the dry skin ten to twenty minutes before the colostomy is opened and is reapplied as necessary. Kaolin powder is often valuable. For protection of the skin in cases of bowel fistula, Friedman[21] has had excellent results with aluminum hydroxide paste. He says: "We found it simplest to prepare this paste from the more liquid aluminum hydroxide gel,† which is already available as an acid absorbent in the treatment of peptic ulcer. Either one of two procedures, equally simple, was used. The commercially prepared gel was poured into wide evaporating dishes and allowed to evaporate with occasional stirring at room temperature for thirty-six to forty-eight hours or until the desired consistency was attained, or else the proper consistency was reached by low speed centrifugation, the supernatant liquid portion being discarded. A third procedure, that of thickening the gel by triturating with powdered calcium carbonate, kaolin, starch and aluminum hydroxide, was also used on numerous occasions; but the paste so prepared, while otherwise satisfactory, was not as smooth as the other pastes and tended to harden and cake much more readily. The paste is applied in thick portions to both the excoriated area and the everted intestinal mucosa, the whole then being covered in the usual manner with several layers of gauze. When the skin is badly eroded or inflamed it is advisable to change the paste dressing every few hours during the first two or three days."

Donald[22] uses a sputum cup strapped to the skin with adhesive tape. The inside of the cup and the adjacent skin are heavily coated with an ointment composed of 50 per cent glycerin and 50 per cent kaolin. MacNaughton[23] describes a method of removing by suction the contents of a *proximal small* bowel fistula and delivering it to the distal loop. The McCollum tube‡ is a useful and valuable aid to sinus drainage. According to McCollum:[24]

"[illegible] of d[illegible] the [illegible] permitting dry dressings at all times; to assure comfort for the patient, and to reduce the cost of dressings and nursing care.

"[illegible]

* Manufactured by the Carbide & Carbon Chemicals Corp., Chicago.
† Aluminum hydroxide gel (Wyeth).
‡ G. A. Ingram Co.

tubing. The opening (*A*) is placed inside the loop (*E*) so that it cannot come into contact with any tissue surrounding the sinus opening (*X*) and thus cannot at any time become plugged by the surrounding tissue. The ends *C* and *D* can be strapped to the abdominal wall so that loop *E* is held comfortably in place and maintains opening *A* at the proper level, which is regulated by pads of gauze *F* and F_1. The bent arm (*G*) is strapped to the abdominal wall, and thus holds loop *E* so that it cannot turn laterally or become displaced. The rubber tube (*H*) is attached to arm *G* and runs to bottle *I*, in which the sinus drainage is collected for accurate measurement. Bottle *I* is connected by rubber tube *J* to bottle *K*, which is used to collect any kickback from the suction pump (*M*). Bottle *K* is then connected by any length of tubing (*L*) to a Penberthy suction pump (*M*), which is attached to the faucet (*N*).

"The use of this tube reduces the care of the patient to the usual routine nursing care, keeps the patient comfortable at all times and makes it possible to keep an accurate record of the volume of fluid losses so that the fluid balance may be maintained, to collect bile when one wishes to return it to the gastrointestinal tract through a nasal tube or to collect fluid from a proximal loop of an ileostomy to be returned to the distal loop through a second tube by means of a rectal drip.

"This tube may be made of glass, bakelite or metal."[25]

The use of a small inflatable rubber balloon is suitable for the temporary control of an ileostomy.[26]

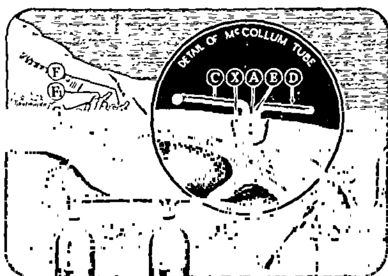


Fig. 585.—Diagram of operation of McCollum tube. (McCollum, E. B.: J. A. M. A. 112: 1821, 1939.)

The device of Moorhead's[27] may be employed after vesical operations. In a case of colostomy wounds, after the skin has been thoroughly cleansed with alcohol and has been dried, it is anointed with zinc oxide or vaselin. A mixture of equal parts of ordinary rubber cement and ether has been recommended. (Webb.)

When *bile* is to be collected from a tube in the common duct, it is important that a receptacle (a whisky flask is useful) for the bile be included in the dressing. *Never* connect a T tube to a bottle beside the bed by means of rubber tubing; the patient may turn over in bed and pull the tube out of the wound. Ravdin and Frazier[28] have called attention to the advantages of gradual decompression following complete obstruction of the common duct. In cases of long-standing biliary fistula the bile can be collected and introduced into the patient's stomach by means of a stomach tube.

A useful method of collecting bile from a T tube is to attach an infant's nursing nipple to a 2 or 4 ounce bottle. The T tube is passed through a *small*

hole made in the end of the nipple, and another hole is made in the side of the nipple for an air vent. The bottle is attached by a tape to the patient's dressing (Fig. 586).[29]

The intern should familiarize himself with the full details of the management of a colostomy.[30] Ingenious appliances for the control of colostomies are the inflatable balloon of Lamson[31] and the vitallium plug of Smith.[32]

[illegible] the wound thus [illegible] ulation tissue is small in amount, it may be removed simply by cauterization with a silver nitrate stick. A pressure dressing is valuable to prevent growth of exuberant granulations. (For deodorization of wounds, see the section on Wounds.)



Fig. 586.—Nipple and bottle used for collecting bile from a T tube.

Walking Crutches and Other Apparatus.—The patient is allowed out of bed *after a certain postoperative period varying with the custom of the surgeon,* the type of operation and the patient's strength. Some surgeons favor early walking (on the second or third postoperative day).[33]

When a patient is ready to walk on crutches it is often the duty of the intern to measure him for the crutches and to assist him in learning to use them. The total length should be about 3 inches longer than the distance from the axilla to the bottom of the heel, but this frequently must be revised with trial. The distance to the hand piece should be such that the patient may easily put his full weight on his hands. The tips should be rubber capped. The patient should be instructed "to bear as much weight as possible on the stiffened rigid arms and to depend on the axillary support as little as he can."[34] The crutches should not be put out too far to the sides (Fig. 587). Lewin[34] calls attention

to an adjustable spring crutch and a rubber crutch pad.[35] Ober[36] has devised a useful crutch attachment for use in cases of paralysis of the triceps muscle. Parker[37] suggests saw horses instead of crutches for elderly persons.

A simple apparatus for application of traction to the leg has been described by Jones.[38] Also useful are the foot support attachments for Thomas splints described by Caldwell[39] and by Schroeder.[40]

Records.—It is the duty of the intern to see that the records of the cases are up to date and complete. This history and physical examination have been mentioned previously. In the proper place in the patient's chart the intern will from time to time (daily in serious conditions) make a brief note of the progress. These notes are invaluable when a later study of the case is to be made. Removal of stitches, removal of drains, changes in apparatus, treatment of complications and changes for better or worse in the patient's condition are all recorded. Consultants had best make their own notes in the charts. All examinations of the urine, blood counts and other laboratory work

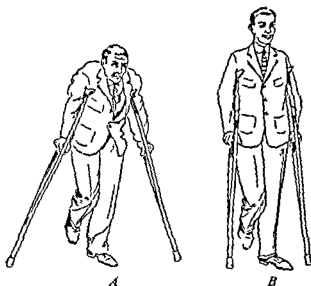


Fig. 587.—*A*, Improper and, *B*, proper use of crutches. (Lewin, P.: J. Bone & Joint Surg 10: 819, 1928.)

should be recorded on the chart by the one who made them. When pertinent, a rough sketch will greatly add to the value of the record. A note as to the condition of the patient on discharge is very valuable.[41]

Laboratory work is not only a duty of the intern but a very important part of his training and experience. The examination of routine specimens of urine in a considerable number will familiarize the intern with all of the normal and most of the abnormal urinary constituents. With systematization of effort and industry large numbers of specimens can be accurately examined in a very short time. The making of red and white blood cell counts, hemoglobin estimations and differential blood counts should become a task of second nature and great ease to the intern. He always should have the pipets, diluting fluid and lancet close at hand. Moreover, he should become thoroughly conversant with the tests for examination of the spinal fluid, with the methods of grouping blood donors (see the section elsewhere), with the examination of stomach contents and stools and the examination of blood

for parasites. He should be familiar with the making of cultures and smears and with their examination for the commoner micro-organisms. No intern should leave a hospital without being able to identify gonococci, tubercle bacilli, diphtheria bacilli, streptococci and staphylococci.

The smear is still the most reliable criterion of gonorrheal infection, but cultures will be consistently positive if the material is obtained in the acute stage of the disease.[42] When the presence of gonorrhea is suspected in females, smears should be made with the aid of a good light and with adequate nursing assistance. Material should be obtained from the vaginal introitus, by expression of Skene's and Bartholin's glands, by expression of the urethra by a finger in the vagina, and from the cervix itself by means of a vaginal speculum. A smear is best made by evenly rolling (not rubbing) a slender sterile cotton swab over a sterile slide.

Persistent intracellular, gram-negative, biscuit-shaped diplococci in freshly made and carefully stained films from the genitourinary tract of a child are presumptive evidence of gonococcic infection, even in the absence of confirmatory clinical and cultural findings.

Accident Ward and First Aid. (See the section on First Aid.)—The intern is on constant call for duty in the accident ward. The most important part of this duty is prompt response to calls for his services. It is part of his duty to see that the accident room is properly equipped with all manner of supplies needed in first-aid work and to familiarize himself with the supplies which are already there. A sterile set of instruments wrapped in a sterile towel always should be in readiness so as to avoid delay. A tracheotomy set, an intubation outfit, a tourniquet and all manner of stimulants should be in readiness. Vaselin gauze and other supplies for the treatment of burns should be available for an unexpectedly large number of cases. The injured person generally is brought in accompanied by a rather large group of excited relatives, policemen, curious bystanders and the like. The room should be cleared of these persons before any procedure is carried out. The first aims of the intern should be to treat shock and to control hemorrhage if present. The diagnosis and treatment of these conditions have been given previously. The subsequent duties of the intern will vary entirely with the nature of the case. It is a great temptation on the part of the intern to do more than is justified, in his anxiety to gain experience. In cases of severe injury it is far better judgment to do the minimum necessary for the comfort and safety of the patient, to notify the attending surgeon of the condition of the patient and to be guided by his instructions rather than to proceed undirected. The many minor injuries, of course, will be treated by the intern without consultation with the attending surgeon, but he should be careful to make a proper record of all that is done. He should not be guilty of the common error of putting in an inordinately large number of sutures in small lacerated wounds. The intern should familiarize himself with the method of accident work and the best methods of caring for wounds before he is confronted with these types of cases. He should continuously review in his mind possible emergencies and their treatment.[43]

In addition to the intern's duties in the accident department he may be called upon to assist in the conduct of the surgical outpatient department. The outpatient department is always a very fruitful field for surgical training. Work skilfully done there is an excellent recommendation for participation

in larger and more involved procedures. The intern should also participate in the follow-up clinic if there is one.

Attendance at Autopsies.—All autopsies should be attended by interns. The great value in pathologic instruction to be obtained from postmortem examinations should be stimulus enough in itself to insure the attendance of the intern. Any intern who does not actively try to be present at all autopsies is under some suspicion as to his real interest and devotion to the study of medicine.

Permission for Autopsies.—Death of a patient very frequently occurs when the attending surgeon is not present. It may be when it is difficult to get the attending surgeon's presence at the hospital. It then becomes the intern's all-important duty to secure from the next of kin of the deceased the permission for postmortem examination. This most unpleasant duty will require great resourcefulness and tact on the part of the intern. The grief-stricken relatives must be approached with kind solicitude and the purposes of the postmortem explained. The intern must carefully refrain from any vivid description of the actual postmortem study. "He explains that it does not disfigure the body; that an autopsy is always beneficial to the professional staff; that the information obtained may be helpful to society at large; and that tumors or other pathologic conditions may be found that would prove to be desirable information to members of the direct family, etc."[44] It will be wise to use such phrases as "the reopening of the wound in order to ascertain if everything possible had been done to prevent the death." The more intelligent person will be influenced by the argument that the examination may reveal information which will be of great benefit to some other patient afflicted with the same condition. One must be sure to stress the point that the individual doctor or intern will probably not personally benefit by the examination but that humanity and society will, through the accumulation of knowledge obtained from many autopsies. Most frequently great opposition is encountered in securing permission for autopsy, and the intern may be required to engage in a painful and tedious argument which will require great patience and forbearance. In case he fails to secure this permission, he should try to keep the relatives at the hospital until the attending surgeon can be summoned to add his persuasion to the intern's. Success in obtaining permission is much more likely to result if the relatives can be approached before they have had conversation with the undertaker. Many undertakers are opposed to autopsy, because it delays their work and increases its difficulty, and they will not hesitate by subtle suggestion to paint the horrors of the autopsy to the relatives. If permission is granted, the nearest relative should sign the printed form provided for the purpose, and this signature should be witnessed. The intern always should inform the attending surgeon of the time when the autopsy will be started.

Hoffman's[45] article on postmortem examinations is so valuable that every intern should read it in its entirety. Christian[46] says: "It has seemed to me that the number of necropsies obtained on patients dying in the hospital is perhaps the best single index of the professional efficiency of the hospital, of the amount of work devoted to the study of patients by members of the staff, of the eagerness of the staff to learn, and its teaching abilities."

Clinicopathologic Conferences, Society Meetings and Collateral Reading.—The intern should inform himself as to the literature pertaining to the patients

in his care. Even a small amount of well directed reading will greatly enhance his understanding of the conditions and will make more intelligent the measures which he employs in their study and treatment. All first-class hospitals should have at least a small library of standard works and the more important periodicals. The intern must make it an important part of his program to attend meetings of medical societies and, if possible, to attend clinics in other hospitals.

The intern should make every effort to attend the conferences given by the pathologic department. At these conferences, whose preparation entails a great deal of work, the material from autopsies and specimens removed at operation are shown and discussed. Interesting sections of pathologic specimens and unusual bacteriologic findings are exhibited and explained. Once or twice monthly, in most hospitals, there is a clinical meeting of the surgical staff at which the attendance of the surgical intern is imperative. The preparation of much of these conferences is often delegated to the senior surgical intern. He will ascertain what deaths have occurred on the service since the last meeting and will select all the most interesting cases, *e. g.*, those of postoperative infections or other complications. He will prepare a list of such cases for the chief of the service and will see to it that all records, *x*-ray films, etc., pertaining to these cases are at hand at the conference. The intern often will be called upon to present cases at both the pathologic and the surgical staff conference. In such an event he should present his case *briefly* and with a good understanding of its essential points. It is very tiresome to have to listen to a long-drawn-out reading of a history and physical examination or to endure an interminable wait while a protracted search is made through the record for some essential point.[47]

The Intern's Health.—There is perhaps no other period in the career of a doctor which is more taxing to his health than the internship. Long hours of responsible duties, frequent interruptions of his night's rest and close confinement indoors have impaired the health of many interns. It is an important duty not only to the intern himself but to the patients as well for him to secure a certain amount of regular outdoor exercise, together with mental relaxation and diversion, and not lose too much sleep in his time off.

RESPONSIBILITIES OF THE INTERN TO THE ATTENDING SURGEON

Notification of the Attending Surgeon of a Patient's Arrival at the Hospital.—As soon as a patient is admitted to the hospital the intern should endeavor to get into communication by telephone with the attending surgeon. In case he is unable to do so, he converses with the patient and uses his best judgment as to the preliminary orders until more specific ones can be obtained from the attending surgeon. Not infrequently, unavoidable exigencies delay the communication between the intern and the attending surgeon. The loyalty of the intern then demands that he reassure the patient's anxiety as much as is possible. He tries to protect the best interests of the attending surgeon in every way. He will be an attending physician himself some day soon.

Rounds.—The intern arranges with the telephone operator at the hospital so that he is notified immediately upon the arrival in the hospital of the attending surgeon. He meets the latter at some appointed place or finds him in the wards and makes the rounds with him. If he is unavoidably prevented from making the rounds with the attending surgeon it is courteous to inform

the latter to that effect. He should always be provided with a notebook in which to note all directions or suggestions given by the attending surgeon as to the patients' care. Changes in orders by the attending surgeon should be written by the intern on the chart or order book. He is present at most examinations of patients and observes the manner in which they are conducted. The surgeon often invites him to inspect or palpate some interesting pathologic condition, but he should not crowd forward to do so unless asked. At the conclusion of the rounds the intern will ask the attending surgeon regarding any points in the diagnosis or treatment of the cases that are obscure to him, and great profit may result from these discussions.[48]

In the evening, or in the absence of the attending surgeon, the intern makes rounds. He gives serious consideration to each patient's condition and writes such orders as will best promote the patient's comfort and safety and will be in line with what he knows to be the ideas of the attending surgeon. In case



Fig. 588.—Mask for surgeons. Note that the mouth and nose are covered. A small aluminum or lead piece sewed into the upper border of the mask permits molding of the mask to the nose for those who wear glasses. The mask should have four to six thicknesses of gauze.

of doubt or when there is serious change in the patient's condition, he gets into telephonic communication with the attending surgeon. It is a wise rule for the intern in his evening rounds to anticipate, if possible, all the needs of the patient during the night. This not only will give the patient a more comfortable night but will save the intern from many interruptions to his sleep. Inexperienced nurses often call an intern needlessly in the night. These calls are based on what the nurse considers a very serious responsibility to her patient, and they should be answered patiently and courteously. A sarcastic or impatient answer may have the effect of deterring the nurse from calling the intern the next time, when he really may be needed.

Assistant at Operation.—Perhaps the chief function of a surgical intern is to assist at operations.[49] The first requisite in this regard is that he be present in the operating room *on time*. It is better that he be there slightly before the attending surgeon and supervise the transportation of the patient to the

operating table. A glance at the instruments not only will familiarize him with them but, by the detection of omissions, may save a considerable loss of time during the operation.

The cap or helmet should be adjusted before he starts to scrub. The mouth gauze should be so adjusted as to cover the nostrils. For the surgeon who wears glasses an aluminum strip is sewed into the upper part of the mask so that it can be bent over the bridge of the nose (Fig. 588). This prevents the glasses from becoming fogged by the breath.

[illegible] only [illegible] of bacteria into the air. The direct spray contamination of talking is greatly reduced by wearing [illegible] preventing the escape of bacteria from the nose and throat of members of the operating room staff." A mask made with flannel inside and gauze outside is the most efficient.[51]* Poth[52] advises having a bib extend from the mask under the operating gown.

In their study of postoperative hemolytic streptococcic wound infections Meleney and Stevens[53] found that 33 per cent of the operative staff at one time had hemolytic streptococci in their throats. At least four thicknesses of gauze should cover the mouth and nostrils. Davis[54] says: "There is no question but that covering the nose as well as the mouth with a well fitting mask made of germ-proof materials should be a standardized procedure in every operating room for the entire operating personnel. I am optimistic enough to feel sure that, in spite of previous masking habits, every surgeon will cover his nose and mouth and will require similar masking for each member of the operating team, as well as attendants and on-lookers, when he apprehends clearly the added danger of infection to which he is exposing the patient unless adequate masking is used."

Bacterial contamination of wounds is discussed by Hirschfeld[55] as follows:

"Infection occurs in from 3 to 5 per cent of all clean operative wounds. Barring a 'break' in technique there are three possible sources from which the bacteria responsible for these infections may come. [illegible] and the patient's own ski[illegible] tory tract of members [illegible] operating team and the patient. The number of these bacteria may be reduced by measures directed toward controlling them at their source. Such measures are observance of silence and use of proper masks, wearing sterile clothing in the operating room, posturing and draping the patient before bringing him into the operating room, and avoiding unnecessary motion and activity. The number of these bacteria can also be reduced by irradiating the air [illegible] con[illegible] duc[illegible] by Hart to be accompanied by a decrease in wound infections. It has not yet been proved whether this decrease in infection is due to a decrease in the number of bacteria falling into the wound from the air, to the destruction of bacteria in the wound which have gained access to it from sources other than the air, to prevention of contamination of the wound by bacteria from the adjacent skin, or to changes caused in the wound itself by the irradiation which make it more resistant to infection. The answer to these questions will determine the type of radiation to be used in the future.

"While the number of bacteria which fall into a wound from the air is relatively small, there is evidence to prove that large numbers of bacteria may escape into a wound through

* These masks may be obtained from Bauer & Black, Chicago.

holes in the surgeon's gloves.

protect the skin during long operations for it has been shown that the number of bacteria that may be recovered from the skin increases as the length of an operation increases."

Hart[56] has made a strong case in favor of ultraviolet irradiation of the air in the operating room. Rice and his colleagues[57] conclude: "While the bacterial content of the air in the operating room may occasionally be a source of infection for the clean surgical wound, we believe its importance has been greatly overemphasized."[58]

The intern starts scrubbing somewhat before the attending surgeon, so that by the time the surgeon has completed his scrubbing the intern will have prepared the field of operation. The hands are thoroughly scrubbed with green soap and water for five minutes. The scrubbing brush should not be dipped back into the receptacle for soap. The soap should be poured on the brush from either a pitcher or an automatic container. An excellent guide to scrubbing of the hands is a five-minute sandglass placed in front of the scrub sink. At the beginning or the early part of the scrubbing the finger nails, which should always be short, are thoroughly cleansed with a nail file which is kept in a dilute solution of lysol. The hands should receive the most vigorous scrubbing, but the forearms should not be omitted. After the scrubbing and frequent rinsings have been completed and the arms and hands are finally rinsed, the hands are immersed in a basin of alcohol and the forearms washed with handfuls of alcohol. This technic varies in different hospitals. The alcohol may be applied to the hands and arms by means of alcohol-soaked sponges.

then allowed to dry for five minutes. At the end of that time the usual scrubbing process is carried out. Bacteriologic tests have demonstrated that tincture of iodine thus employed will completely sterilize the spaces about the nails.

accurately, the amount of friction produced at the surface. Rinsing without friction has practically no effect on the resident flora. Washing by rubbing the hands together is far less effective than scrubbing with a brush. A soft brush is less efficient than a stiff one. Vigorous

dirt and then the hands should be scrubbed conscientiously for seven minutes (on the average), with warm (city) tap water, abundant soap, a brush of medium stiffness with well packed bristles of equal length. The scrub-up will remove about half of the resident flora.

Further reduction of that flora is best accomplished by means of chemical disinfectants When gloves are changed between operations, there is no need to scrub the hands unless they have become contaminated, when only two or three minutes is required. Beneath the gloves the resident flora will have increased, however, so use of a germicide between operations becomes necessary." Pijoan and Wheeler[62] say that "skin within thirty hours of shaving has an increased permeability to percutaneous invasion." Lovell[63] says: "Under normal conditions skin bacteria are located on the surface embedded in the horny fat, in the crypts, and crevices, hair follicles, and sebaceous glands. Most of the transient organisms of the skin are quite superficial and can be removed by mechanical and chemical cleansing. The resident bacteria are situated so deep in the hair follicles and sebaceous glands that they cannot be removed by mechanical means without injuring the skin; the generally used antiseptics do not penetrate sufficiently to reach the organisms located in the deeper parts of these structures. Although the surface of the skin may be rendered relatively free of bacteria by mechanical and chemical cleansing before operation, during operation the resident bacteria rise to the surface, multiply, and thus constitute an important source of wound contamination."[64]

The intern then picks up the folded sterile gown and opens it. It is folded so that the side of the gown which goes next to the person is outermost. The hands are inserted into the sleeves, and the gown is partly slipped into. The nurse then draws on the gown from behind and ties it, taking care not to contaminate the front part of the gown. The gown should not be touched with the bare hands. The hands are then dried with a sterile towel and powdered with talcum powder.[65] There is a right and a wrong way to put on sterile gloves. The gloves should be sterilized with the cuffs turned back. The powder puff should be inside of the glove. After this has been removed and his hands dusted, the intern grasps the left-hand glove at the edge where it is turned back with the right hand and draws it on the left hand. He then places the gloved left hand under the folded cuff of the right-hand glove and draws that glove onto the right hand. It is better for the nurse to hold the glove open while the surgeon puts his hand in it. If a glove is torn or perforated it must be replaced immediately.[66] The end of the gown sleeve is then folded over and the rubber cuffs drawn over it. All talcum powder should be washed from the gloves in a basin of sterile water before the operation begins. The basin of water for this washing should be discarded after all members of the operating team have used it and replaced by a fresh one. Lichtman and his associates[67] believe that talcum powder should not be used in the operating room. In long-armed individuals, for whom the gown sleeve may be too short, the wrists are covered with stockinet wristlets. In summer a damp towel tied about the forehead is a great comfort. The intern who wears glasses should make sure that the mouth gauze passes beneath the lowermost rim of his glasses, to minimize fogging of the glasses by breath. The mouth gauze should be provided with a flexible piece of metal, usually a strip of lead, sewed in its border to bend over the bridge of the nose to insure a more accurate contact of the gauze with the face.

A second pair of rubber gloves termed the "preparation gloves" may be drawn on over the first pair. These are to diminish the danger of contamination if the intern prepares the field of operation. The intern then drops a sterile towel at the side of the patient and between him and the operative field. This is to minimize still further the chances of contamination. He is careful not to permit his gown to touch the unsterile drapes or the operating table itself. The nurse then holds up for the intern the sterile preparation tray with material for preparing the field for operation. For painting the field of

operation a gauze pledget tied to the end of a tongue depressor is useful. Small cups contain the various solutions used in the preparation.

Various methods are used to prepare the skin of the field of operation. Prolonged cleansing with soap and water is advised by Koch. Usually, however, various solutions are painted on the dry skin. Hatfield and Lockwood[68] conclude that "ethyl alcohol in strengths of 95 per cent and 70 per cent by weight is preferable to any of a group of commercially prepared agents specifically designed for skin sterilization."[69] "Mercresin" has been found to be very efficient and non-irritating. Maddock, Boyden and Malcolm[70] tried tincture of "mercresin" as a preoperative skin antiseptic and concluded that it had the following advantages:

"(1) High germicidal and bacteriostatic properties. (2) Rapid action. (3) Satisfactory penetrability. (4) Sufficient color to define the extent of the field prepared as well as the ability to lose this color rapidly. (5) The ability to dissolve fat and degenerative cellular débris from the skin surface.

"[illegible]

propanol.

Zephiran chloride* as an aqueous solution or a tincture is an excellent agent to use in preparing the skin of the field of operation. Shumacker and Bethea[72] find it a cheap and reliable germicide and recommend it for preparation of the hands before operation. Helmsworth and Hoxworth[73] say: "Scrubbing operative fields with a 1:100 aqueous solution of cetylpyridinium chloride produced a striking germicidal effect."[74] Four per cent carbamide peroxide in substantially anhydrous glycerol is praised by Brown and his associates.[75] Price[76] prepares the field of operation with 70 per cent by weight alcohol followed by iodine or some other strong antiseptic. DeBakey and his colleagues[77] used vinylite resin to prepare the skin for operation. (See the discussion of protection of the skin in ileostomies.)

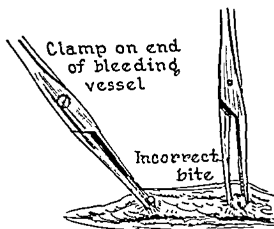
For very delicate skin or about the genitalia the acetone-alcohol-mercurochrome solution is used. The portion of the skin in which the incision is to be placed is first painted, and the adjacent portions in a gradually enlarging field are then treated with the solution. Great care must be observed not to permit the solution to run down in the groin or down the side of the patient to the back, as troublesome burns may result. When there is fear that the skin will become burned by the iodine, the latter is washed off with alcohol.

The "preparation gloves" are now removed by means of the turned-back cuff by the nurse; the intern then places four sterile towels on the four sides of the operative field, leaving ample area of the painted skin exposed and being careful not to contaminate his sleeves, hands or gown. The "scrubbed" nurse will then put the laparotomy sheet in position. The latter has been so folded and is so placed that the window in it will lie opposite the field of operation. The nurse who places the laparotomy sheet must take care that she does not drag it over the patient's body, because this might carry contamination from an unsterile to the sterile field. Lahey[78] has devised a method of clamping operating sheets in goiter and neck operations so that instruments may be prevented from falling on the floor. The Trendelenburg table, or Mayo stand, is placed 8 or 10 inches higher than the patient's shins, over

* Winthrop Chemical Co., Inc.

which it rests. The fold of the sterile sheet covering the patient is then fixed by hemostats to the sterile pocket cover over the Trendelenburg table, and the folded portion of the sheet is likewise made fast at the head of the table to the sheet, which is turned upward over the anesthetist's bar. This forms a side wall of sheeting on each side of the patient's chest and abdomen, making a rectangular trough into which instruments and needles readily fall when placed on the patient's body in semi-reclining position. The intern should now take his place opposite the operating surgeon. If a second intern is in attendance, his place is at the right hand of the first intern. If there is a third assistant, his place is at the surgeon's left hand.

The watchwords of good surgical assistants are alertness, accuracy, helpfulness, silence and avoidance of obstructing the surgeon's efforts. With a little practice the intern will soon learn to anticipate the surgeon's wants without being told. He should always have in his hand a hemostat or a sponge and should always have his hands usefully occupied. He should be extremely careful *not to interpose his hands* between the surgeon's eye and the field of



g 589.—Correct and incorrect methods of clamping a bleeding vessel. Too large a bite is not good.

operation and should avoid the bad habit of becoming so interested in the operation as to bend over and interpose his head between the surgeon's eyes and the field of operation. He should not take his *eyes off the wound* any more than absolutely necessary. If an instrument is wanted, he should not reach for it blindly on the instrument stand but should ask the nurse for it and extend his hand to receive it. Particularly should he not take his eyes from the wound when one of his hands is holding some piece of tissue or instrument with which the surgeon is working. The momentary deviation of his eyes will make that tissue or instrument tremble, *much to the annoyance* of the surgeon and possible danger to the patient.

The intern should strive to anticipate the surgeon's needs. He should know when to retract without being asked and should select the proper type of retractor. He should so grasp the retractor that it is held *with a minimum of* effort, and he will not permit it to slip out of position. When the field becomes obscured by blood, the latter is *sponged* away. All blood should be *sponged* or blotted away and not wiped away. Wiping an oozing field destroys the efforts at coagulation and only serves to continue, or to increase, the hemor-

rhage. The intern should sponge quickly, and the bloody sponges should be placed in the proper receptacle. He should be extremely gentle with all his manipulations. Rough handling with consequent traumatization of the tissues is to be shunned. When the surgeon's scalpel severs a vessel, either artery or vein, the intern grasps the cut ends with a hemostat. He should grasp the cut end with only as little as possible of the adjacent tissues (Fig. 589). In case the bleeder is difficult to grasp, he assists the surgeon in his effort to grasp it by retracting and sponging. When a vessel is to be tied, the surgeon directs who is to tie it. Should he elect himself to do the tying, the intern holds up the handle of the hemostat so the ligature can be easily passed around behind it. When the ligature has been passed around behind it, the intern drops the hand and elevates the tip of the hemostat which has grasped the cut vessel in order that the surgeon may have a better opportunity to tie the knot (Fig. 590). As soon as he has taken off the hemostat he provides himself with scissors and cuts the long ends of the ligature to the length indicated by the surgeon. The cutting of these ends must be accurately done. Too long ends are objectionable, and too short ends weaken the knot. The intern must

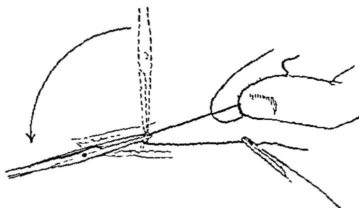


Fig. 590.—When the ligature is to be knotted, the handle of the hemostat is dropped and the point is elevated.

observe particular care in cutting a ligature so that the points of the scissors do not enter the bowel or other important structures. If necessary he should steady the points of the scissors with the other hand. The surgeon may elect that the intern tie the ligatures. In this case it is often to the intern's advantage that he learn to tie with a hemostat at one end of the ligature. He should tie square knots only (Fig. 591), and if necessary should practice this procedure with a piece of string when not assisting at an operation.

Taylor[79] has made an interesting study of surgical knots. He says: "Many suture failures are due to the knot rather than the suture material. . . . The safest of all common surgical knots is the triple throw knot. This is safest when all throws are tied square but is also quite

ever, catgut is most suitable for the mucosa and submucosa and in other situations (procto-logic operations).[82] *Cotton* is preferred by Meade and Ochsner[83] who place silk in second, [illegible] recommended by Aries[85] and Nichols

chromic to plain catgut and uses the smallest size. [illegible]

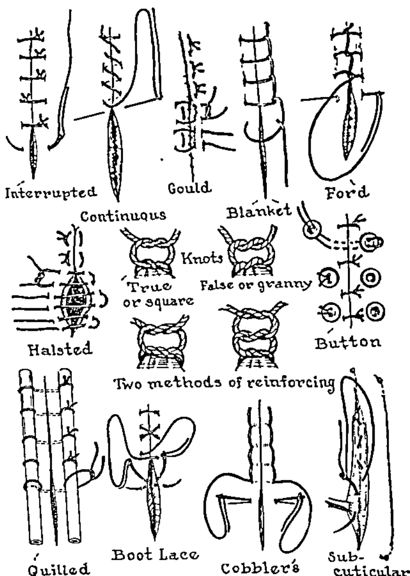


Fig. 591.—Various types of knots and sutures. (After Tom Jones, in Luken: Suture and Ligature Manual.)

on the absorption time of catgut in 164 surgical cases. "Three hundred and fifty-eight strands of catgut were tested. The observations made were as follows: (1) Small sizes of catgut last as long or longer than large sizes; (2) single strands of catgut last as long as double strands; (3) labels which indicate the length of time necessary for absorption of catgut are entirely fallacious in so far as the human being is concerned; (4) drainage and suppurating wounds do not cause early absorption of catgut; (5) variation among individuals in the absorption time of catgut is great, and (6) certain brands of catgut consistently last longer than other brands."

* The U. S. Pharmacopeia will now officially use the term surgical gut in place of catgut.

Stainless steel wire is used by many surgeons, and it is believed by some to be superior to silk or catgut.[92] Wu and Pai[93] say: "In order to facilitate the tying of wire sutures and the regulation of the tension exerted by them on the tissues within their grasp, we recommend elimination of the customary knot and fixation of these sutures by simple twisting of the ends of the wire for three complete turns."

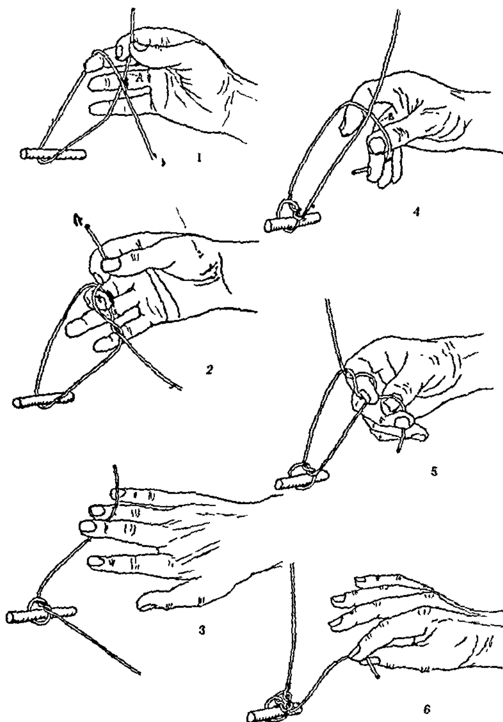


Fig. 592.—Steps in tying one-handed knot. (Meynen, F. G.: J. A. M. A. 85: 579, 1925.)

Meynen[94] has described an excellent method of tying a square knot in which only the right hand is directly used. He described his method as follows (Fig. 592):

"It is essential to remember that the long end (if there is a choice) should always be grasped by the left hand. In the drawings, for the sake of simplicity, the long end is left free without indicating the left hand.

"Assuming that the long end comes out of the wound on the far side from the surgeon about to tie the knot (as is the case, for example, when the first knot in a continuous suture is tied by an assistant for the operator), it is grasped by the left hand, while the short end

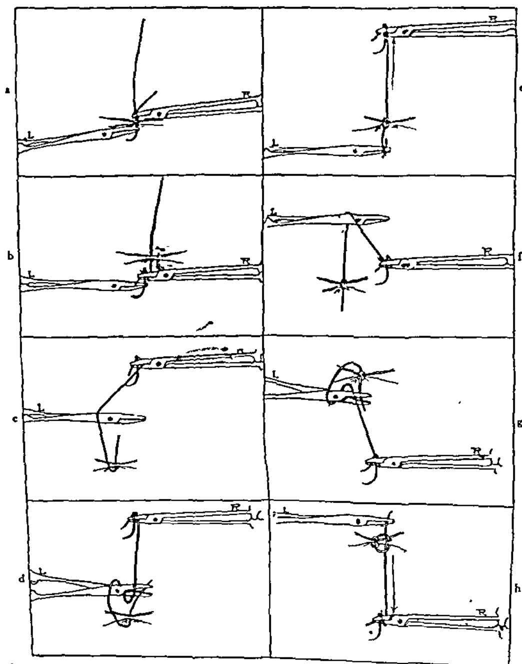


Fig. 593.—Tying square knot by means of instruments. (Livingston, E. M.: Am. J. Surg. 6: 121, 1929.)

is grasped about 1 inch from the end between the thumb and index finger of the right hand with the palm down. The palm is immediately turned upward with the suture lying across

fingers, the palm is turned somewhat upward, the thumb and first finger being placed under the suture and the long end in the position shown in Fig. 592, 4. The tip of the index finger is then hooked under the portion marked *B*, as in Fig. 592, 5, drawing it through the loop and grasping it between the thumb and index finger as soon as it is through, and the knot is drawn tight and completed as in Fig. 592, 6. Should a third knot be desired, the hand will be found in a position ready to repeat the first maneuver from Figs. 592, 1–592, 3.

"*Should the surgeon be desirous of tying his own suture (in which case the short end* will come out on the far side of the wound and the long end on the near), he has only to begin with the maneuvers depicted in Figs. 592, 3–592, 6 and end with Figs. 592, 1–592, 3.

"This method is particularly suitable and rapid for ligating vessels with a long ligature wound around the fingers of the left hand. It must be remembered, however, to begin with Fig. 592, 1, when the long end comes up on the far side of the clamp, and with Figs. 592, 3–592, 6, and then Figs. 592, 1–592, 3, when the long end comes up on the near side of the clamp. This decision will come instinctively with practice."

It is extremely valuable to learn how to tie knots with instruments only (Fig. 593).

The intern should not place his hand in the patient's abdomen so as to palpate a pathologic condition unless invited to do so by the surgeon. In appendectomies in which the appendix is removed with inversion of the stump, the intern should be careful not to lose control of the stump prior to its inversion. The intern should be on the alert to grasp the surgeon's needle after its point has projected through the tissues, particularly when this occurs in the depths of the wound or in some inaccessible place. Penfield[95] has devised a simple needle-pulling forceps. It is a saddle-shaped piece of metal which may be attached to the operator's favorite thumb forceps. It is particularly useful for the surgeon himself, who holds it in his left hand as he sews. For the intern an extra needle holder is useful for this purpose.

After the incision has been made and preliminary hemostasis secured, towels are clamped into the wound margins. This preferably is done by laying the towel at the edge of the wound, so that the body of it lies across the wound. The towel itself is then fastened into the wound by proper towel clips and turned back over so that the clips are covered and so that the towel actually extends into the wound. The same procedure is carried out on the opposite edge of the wound, and the two towels are clamped together at the ends of the wound by a hemostat placed beneath them. When the surgeon is closing the peritoneum or the fascia, the intern should keep a constant tension on the suture, so that the stitches already placed will not be permitted to loosen.

Blair Bell[96] has called attention to the fact that a large percentage of incisional hernias are due to imperfect suture of a laparotomy wound. The essential requirements, apart from asepsis, of a perfect procedure in the closure of an operative opening in the abdomen are given by Bell as follows:

[illegible] through the sutured peritoneum. (2) The prevention of

Difficult closures are greatly aided by intelligent assistance, such as proper retraction and the gentle pushing of the abdominal contents back into the abdomen by means of gauze or blunt instruments.

Should the intern accidentally puncture one of his gloves with a needle or

some instrument, he must immediately change it. Collins and Ritz[97] made a bacteriologic study of surgical infections and concluded that the chief source of postoperative infections is punctured rubber gloves.[98]

When the skin is closed, the intern makes sure that there is no inversion of the skin edges. A sterile dressing is placed upon the skin wound, and the excess "prep" solution at the borders of the dressings is washed off with alcohol. The intern then fastens the dressing in place with elastic adhesive* or, if this is not obtainable, with ordinary adhesive, usually taking care that the plaster does not pass over the anterior superior spine of the ilium and that it is not too tight. In cases in which a drain is inserted and frequent changes of dressing will be necessary, the tape or laced adhesive plaster should be used. Rayon[99] and moss[100] have been used for surgical dressings. In case the skin is markedly sensitive to adhesive plaster, the gauze dressing may be attached to the skin with the flexible plastic-liquid adhesive described by Rosenberg.[101] The formula is: Polyvinyl butyral resin,† 20 Gm.; alcohol (95 per cent), 120 cc.; ether, 20 cc., castor oil, 10 cc. In some cases it will be advisable to employ a "many-tailed" flannel bandage (scultetus bandage). The "tails" are carefully folded over, first one side and then the other, beginning at the lowest part. When the top is reached the last tail is made fast with a safety pin.

In warm weather the intern should be careful that perspiration does not drop from his forehead onto the field of operation. When his forehead becomes moist, the perspiration should be wiped off by a nurse. In long operations an intern has been known to become faint. If he feels this fate impending, he should excuse himself for a rest rather than remain there with the possibility of actually fainting.

A word of caution may be spoken as to the danger of slippery floors in the operating room. The writer has seen a broken arm result from incautious haste in an operating room. Unnecessary moving about in an operating room greatly increases the opportunity for accidental contamination. Attention to this point has brought fruitful results. Eugene H. Pool, of New York, had an architect's plan made of the operating room, and during a standard operation had lines traced on the plan to mark all the steps made by the individuals in the operation. Before his efficiency methods were instituted, the complexity of the pattern of these lines was astonishing.[102]

To insure efficiency and silence in the operating room Pool devised a signal system for securing instruments. The surgeon and assistants signal to the scrub nurse by various positions of the fingers for various types of instruments. This is particularly valuable when local anesthesia is employed.

When operations are performed under local anesthesia an intern is often assigned to the duty of staying at the patient's head, diverting his attention with suitable conversation and encouraging him. An intern's usefulness may be quite accurately measured by his reaction when something goes wrong in the operating room—a large bleeding vessel has escaped control, the trachea is inadvertently opened in a thyroid operation or the bowel is accidentally punctured. His equanimity and skill will greatly fortify the surgeon in meeting the unpleasant situation.

* "Elastoplast."

† The polyvinyl butyral resin used in this experiment was Vinylite XYSC, purchased from the Carbide and Carbon Chemical Corporation, New York.

been covered by two to four layers of gauze or a thin towel, the operator takes a deep inspira-

thorax. In children, however, care should be taken that

respiration. Mechanical respiration, unless so forcible as to be harmful, does not increase the volume of natural breathing. Inhalation of carbon dioxide and oxygen increases the efficiency of manual artificial respiration but increases the antagonism between mechanical respiration and natural breathing."

arrest of serious arterial hemorrhage as an urgent surgical emergency.

The special point to raise is that cardiac massage should be resorted to earlier. If the abdomen is open, massage can be resorted to sooner than otherwise would be the case. To be permanently effective, cardiac massage must be instituted within three and a half to four and a half minutes. With but three to three and a half minutes each member of the operating team must know his or her duty. A junior nurse should be detailed to cry loudly each passing minute from the time the anesthetist sounds the warning note of danger.

Artificial respiration must be started at once, and continued throughout the endeavor. Intratracheal insufflation of oxygen and carbon dioxide is the ideal form of artificial respiration. Silvester's method is efficient if the airway is kept clear.

The surgeon makes an incision in the midline through the linea alba, large enough to insert the hand and starts cardiac massage from below the diaphragm, at first with a quick forcible movement for half a minute—the base of the left hand over the lower thorax aiding in the maneuver. If there is no response after thirty seconds, the movement should be changed to a slower rate of about eighty per minute. A nurse fills a syringe with 1 c cm. of adrenalin and injects it into the heart. Immediately afterward massage is continued. If there is no success the surgeon detaches the diaphragm from the left costal margin with a stroke of the scalpel and the opening is stretched to take the hand; he then rhythmically squeezes the heart within the pericardium. If the last maneuver is successful the opening in the diaphragm must be closed with catgut stitches.

Barber and Madden[110] say: "The transthoracic approach is the method of choice in the performance of cardiac massage. Exposure of the heart is obtained through a transverse incision in the left third or fourth interspace, the adjacent costal cartilages sectioned and the corresponding ribs widely retracted. Manual massage of the heart is the most effective means of initiating cardiac contractions. If uniform success is to be obtained, massage must be performed within three minutes following cessation of the heart beat."[111] Lium[112] reports a case of cardiac arrest after spinal anesthesia, with recovery. He says: "Whenever respirat tion ceases under spinal anesthesia one should be certain that the heart is functioning. I the heart is not beating and the abdomen has not been opened, a laparotomy should be done immediately and cardiac massage instituted. This procedure, if undertaken early enough, may save life by returning the heart to its normal function." Following the report by Darling and Lane in 1902 of the first successful case, only 50 permanently successful cases had been reported in the literature by 1943. Adams and Hand[113] report a case of twenty-minute cardiac arrest with complete recovery.[114]

Notification of Attending Surgeon of Unfavorable Progress of the Patient.— The intern should notify the attending surgeon immediately of any unfavorable development in a patient's condition no matter how trivial it may seem to be. A well intentioned intern often may try to spare the attending surgeon the bother of a telephone conversation and may assume more responsibility

than is warranted, but the attending surgeon will greatly welcome any information of this type.

Operations by Interns.—Unfortunately many interns judge the value of a surgical service by the number of operations they may actually perform themselves. It is, of course, essential that the intern be permitted to do a certain number of operations, whose nature will depend upon the length of apprenticeship which he has had and upon the demonstration of his fitness to do them. By far the most valuable part of a surgical internship, however, is the training of the intern in diagnosis, his education in good surgical methods, his repeated observations of all types of pathologic conditions and his acquisition of knowledge of how to understand patients and how to deal with them. The mechanical side of operating may readily be acquired by any one of average deftness. A distinguished teacher once said: "The operating room serves as a laboratory in which the clinical and pathologic pictures are correlated, rather than a laboratory where surgical technic is demonstrated."[115] Even the unsteady hand may become a useful operator. As Treves has said, "The shaking hand may be somewhat of an impediment to the completion of an operation, but the shaking mind is hopeless." When an intern is permitted to perform an operation, it always should be done with an attending surgeon acting as assistant. This duty of the attending surgeon will be much more tiresome than doing the operation himself, but it is a necessary part of his responsibility to the intern.

Physical and Occupational Therapy.—The intern should become thoroughly familiar with the various types of treatment which are given in the physical therapy department and their indications.[116] He should instruct himself in the various methods of giving massage in order that he may be able to give the proper instructions for its administration. He should understand the various uses of diathermy and should be competent to give a treatment. He should understand the various methods of giving external heat, *e. g.*, by means of the infra-red lamp, radiant heat, hot fomentations, etc. He should understand the uses and the limitations of ultraviolet therapy. He should understand the treatment of paralyzed muscles by the galvanic and sinusoidal currents.

Jones[117] predicts that in consequence of the advances made in the treatment of fractures, the "massage departments" of hospitals will undergo a great transformation during the next few years. A patient with a fractured limb can be persuaded that it is safe to use it only if he is instructed in occupational activity under supervision. In Jones' physical therapy department at the Liverpool Royal Infirmary the number of patients who are actually being massaged is reduced to a negligible minimum. But every patient goes into the department as soon as roentgenograms have shown that the fracture is perfectly reduced. The man whose Pott's fracture was reduced yesterday is today being taught to walk. The woman who sustained a Colles fracture yesterday is today learning to make beds and peel potatoes. As far as possible, individual occupational activity is maintained throughout the period of immobilization. The patient with the fractured spine, whose trunk is encased in plaster, is taught exercises for the erector spinae, which are far more effective than faradic stimulation, even if such were possible. Every patient whose knee joint is immobilized, whether he walks or not, is taught tonic

Suggestions for Starting Physical Therapy in Fractures (Pemberton, Coulter, and Mock)

Bone	Part of bone.	Immobilization.	Position.	Duration of splinting.	Convalescent brace.	Physical therapy; time to begin.	
						Massage.	Active motion.
Clavicle.	Outer, mid inner thirds	1 Clavicular cross	Shoulders' Back up and out	3 to 5 weeks	None	None	Immediate.
		2 Sayre	Same	3 to 5 weeks.	None.	10 days.	2 weeks
Scapula.	1. Body.	Sayre.	Arm to side.	4 weeks	Sling 2 weeks.	1 week.	4 weeks.
	2. Neck	Sayre	Arm to side	4 weeks.	Sling 2 weeks.	1 week.	4 weeks.
Humerus.	Anatomic neck.	Abduction splint	Arm abducted	6 weeks.	Sling none to 2 weeks.	2d day	5 weeks; elbow at once
	Tuberosities	1 Splint. 2. Operation.	Arm abducted.	6 weeks.	Sling none to 2 weeks.	2d day.	5 weeks; elbow at once.
	Epiphyseal separation	Abduction splint	Arm abducted and external rotation.	6 weeks.	Sling none to 2 weeks.	2d day.	2 to 4 weeks; elbow at once.
	Surgical neck	Thomas arm or airplane	Arm abducted and slight forward flexion	6 weeks.	Sling none to 2 weeks.	1st week.	4 to 8 weeks; elbow at once.
				6 weeks	Sling none to 2 weeks.	1st week.	4 to 8 weeks; elbow early
		Operation.	Abducted.	6 weeks.	Sling none to 2 weeks.	1st week.	4 to 8 weeks; elbow early.
	Shaft	1. Jones humerus splint	Arm to side	4 to 8 weeks	Coaptation splints and sling 2 to 4 weeks	3d week.	6 to 8 weeks; elbow at once.
		2 Traction in Thomas arm splint.	Abducted	4 to 8 weeks	Coaptation splints and sling 2 to 4 weeks.	1 to 3 weeks.	
		3 Operation.	Abducted.	4 to 8 weeks.	Coaptation splints and sling 2 to 4 weeks	1 to 3 weeks.	
	Lower end. 1. Supracondylar 2. Diacondylar. 3. External condyle 4. Epiphyseal. 5 Internal condyle. 6. Intercondylar. 7. Epitrochlear.	Plaster-of-paris splint	Elbow hyperflexed.	2 to 3 weeks.	Sling 3 weeks	On removal of plaster splint.	3 weeks; avoid passive motion because of danger of excessive callus of myositis ossificans.
Ulna.	Olecranon	Molded splint.	Extension	2 to 4 weeks.	Sling 2 weeks; gradually increasing flexion.	1 week.	2 to 3 weeks.
	Coronoid.	1 Molded splint 2 Strapping	Flexion	2 to 4 weeks	Sling 2 weeks.	1 week	2 weeks.
	Shaft alone.	Molded splints	Midpronation	3 to 4 weeks	Sling 2 weeks.	1 to 3 weeks.	2 weeks.
Radius	Head.	1 Anterior angular splint	Elbow at right angle in full supination.	2 to 3 weeks	Sling 1 to 2 weeks.	3d day.	Flexion 1 week; pronation and supination 2 weeks.
		2. Operation· remove head	No splint	... ...	None.	3d day.	3d day.

Radius (cont'd).	Shaft alone.	Molded splints	1. Above insertion of *pronator teres, supination*; elbow at right angles 2 Below pronation with elbow same.	4 to 6 weeks.	Sling 2 to 3 weeks	1 week.	2 to 4 weeks.
Both bones.	Shafts.	1. Anterior and posterior wooden splints, plaster splints. 2 Thomas arm and traction.	Forearm supinated, elbow flexed to right angle. Same	5 to 7 weeks 5 to 7 weeks.	Sling 2 to 3 weeks. Same.	1 week. 1 week.	4 to 6 weeks. 4 to 6 weeks.
Radius.	Colles'.	Molded plaster.	*Hand abducted*, pronated and flexed.	2 to 3 weeks	*Wrist strap* 1 *to* 5 weeks.	2 days.	1 week.
Carpus.	....	Molded plaster; cock-up.	Hand extended at wrist.	4 to 6 weeks	Wrist strap 2 to 6 weeks.	1 week.	4 to 6 weeks.
Metacarpus.	Shaft.	Traction in banjo splint; ball in palm	Extension Fingers flexed.	3 to 5 weeks. 3 to 5 weeks.	None.	2 days.	3 weeks.
Phalanges.	Shaft.	Finger splint. Traction in finger cali-*pers*.	Flexion or extension. Extension	3 weeks. 3 weeks.	None. Palmer splint 1 to 2 weeks.	3 days 2 days.	3 weeks. 3 weeks.
Pelvis.	Any bone.	Swathe and suspension in Balkan frame *Rest in bed only.*	Supine.	4 to 12 weeks. *4 to 12 weeks.*	Preferably none. Belt.	1 week.	5 to 8 weeks.
Femur.	Neck. 1. Impacted. 2 Displaced.	Whitman position; plaster spica to toes and opposite side	Full abduction extension internal rotation	12 to 15 weeks.	Calipers and crutches 6 to 9 months; weight bearing 6 to 9 months	12 to 15 weeks.	12 to 15 weeks.
	Intertrochanteric and base of neck.	Same	Same.	8 weeks.	Calipers and crutches 4 to 6 months.	8 weeks.	8 weeks.
	Shaft.	*Thomas splint with* traction.	*Hip flexion; knee flexion*, abduction?	*Skin or skeletal* traction 5 to 9 weeks.	Calipers and crutches 3 to 6 months.	Immediate.	Knee 2 to 4 weeks.
	Supracondylar.	Same.	Hip and knee flexion.	Skin or skeletal traction 5 to 9 weeks.	Calipers and crutches 3 to 6 months.	Immediate.	Knee 2 to 4 weeks.
	T fracture into knee joint.	Same.	Hip and knee flexion.	5 to 9 weeks.	Same as above.	Immediate.	2 weeks.
	Separation of lower epiphysis.	Plaster cast; toes to groin.	Knee flexion.	3 to 4 weeks.	Plaster cast gradual extension of knee.	3 to 4 weeks.	3 to 4 weeks.
Patella	....	Post splint or operation.	Extension.	Post splint or split cast 1 to 3 weeks.	Molded plaster posterior 4 to 10 weeks.	Immediate if pos-*sible*.	7 to 10 days when wound is healed.

SUGGESTIONS FOR STARTING PHYSICAL THERAPY IN FRACTURES (Cont'd).

Bone	Part of bone.	Immobilization.	Position.	Duration of splinting.	Convalescent brace.	Physical therapy; time to begin.	
						Massage	Active motion.
Tibia	Tuberosities.	Thomas splint and traction 4 to 6 weeks, plaster splint or splint cast.	*Extension.*	Same as above.	Calipers 4 to 12 weeks.	*Immediate*	*2 weeks.*
	Shaft of both bones.	1. Thomas and traction. 2. Operation. 3. Plaster cast. 4. Plaster splint.	Knee flexion; foot at right angle; avoid *rotation.*	*6 to 8 weeks.*	Caliper or Delbet 4 to 8 weeks Plaster *splint 4 to 8 weeks.*	1 week	4 to 6 weeks
Fibula.	Shaft.	Molded plaster toes to knee or just above knee.	Knee flexion.	3 to 4 weeks.	None.	2 weeks.	2 weeks.
	Pott's.	Plaster toes and knee.	Dorsal flexion and inversion of ankle.	4 to 6 weeks.	Short calipers; felt foot pad and Thomas heel	Immediate.	2 weeks.
Os calcis.	....	1. Plaster. 2. Operation.	Slight plantar flexion and inversion.	6 to 10 weeks.	Felt foot pad: Thomas *heel; inner borders;* shoe and heel raised $\frac{1}{8}$ to $\frac{1}{4}$ inch.	2 to 3 weeks	4 to 6 weeks
Tarsus.	....	1. Plaster cast. 2. Operation.	Right angle flexion and *inversion.*	4 to 6 weeks.	Same as above.	3 to 4 weeks.	*4 to 6 weeks*
Metatarsus.	Shaft.	Davis splint or cast.	Inversion and plantar arch preserved.	4 to 8 weeks.	Same as above.	3 to 4 weeks.	4 to 6 weeks.

exercises for the quadriceps, and if a patient is due for admission to a hospital for a knee operation he is first taught quadriceps drill until he is so expert in his exercise that he can practice it from the day of operation onward. In short, modern treatment anticipates the complications of muscle wasting, joint stiffness and mental fear, and, instead of treatment being prescribed after these conditions have developed, steps are taken to prevent them from appearing.[118]

Pemberton, Coulter and Mock[119] have furnished some interesting suggestions based on the "Outline of Treatment of Fractures,"[120] for starting physical therapy in cases of fracture. (See the accompanying table.)

The intern should be fully cognizant of the workings of the occupational therapy department. He should constantly be on the look-out for types of conditions which will be benefited by this department and should cooperate with the workers in this department in seeing that the most useful type of therapy is given.

Hinton,[121] who has given a most interesting description of the working of an occupational therapy department, says that his patients with joint fractures are referred for occupational therapy in preference to physical therapy.

[illegible]

cannot restore function or circulatory efficiency by physical therapy without normal muscular activity. Active motion within pain limits is the means of regaining function: guided active motion; gently resisted active motion; active motion with the patient's mind concentrated on some useful, purposeful aim, rather than on the actual motion that he is making. This is much better than aimless exercises. Passive motion is a confession of inability to secure active motion. It may infrequently be necessary, but its use is always deplorable. Its use in children may be regarded as a calamity.

"One may use what physical therapy one will, then, in the late stages, but it must be [illegible]

"Anything that makes it easier for the patient actively to exercise function is good physical therapy [illegible] nothing [illegible] as thous[illegible] harm. I [illegible] just as much the physical therapist's as it is the physician's part to implant in the patient's mind the proper valuation of late physical therapy in treatment of fracture."[123]

Böhler[124] says: "If a fractured joint is accurately reduced and maintained constantly in good position until bony consolidation has taken place and at the same time the fractured limb is used, a freely movable joint is usually obtained, but if, from the first day, massage is given and passive movements are made, the joint becomes stiff or loose." In fresh bone fractures and joint injuries, massage and passive movements are dangerous, as they can be carried out only by interrupting the immobilization, thus favoring redisplacement of the well reduced fragments. All physical therapeutic measures, including massage and passive movements, should be delayed until bony union has taken place. (Böhler)

Interns and attending surgeons are referred to Murray's[125] article for a detailed account of the exact role of physical therapy in the treatment of fractures.[126] Lowman[127] stresses the importance and benefit of exercise in a pool. Huston[128] shows in detail the application of occupational therapy in the treatment of fractures. For an account of occupational therapy at the Mayo Clinic, see the article by Hench and Pattee.[129]

Anesthesia.—And, finally, the intern should learn as much as possible about the administration of anesthesia. In most hospitals at the present time salaried anesthetists are employed who give all the anesthetics. It is desirable that the intern be given some instructions by these anesthetists in the indications and restrictions of the various types of anesthetics. He should know the best type of anesthetic for each type of case, and, what is perhaps most important, he should be competent to tell when an anesthetic is being given poorly and what the proper measures are for remedying the difficulty. In case of disaster during the administration of an anesthetic the intern should understand the proper restorative measures. Dodd and Prescott[130] studied during operations the effect of methedrine on patients with unduly low systolic or pulse pressure and concluded that clinically methedrine is "superior to adrenalin, ephedrine, and pholedrine as a pressor agent." Coramine and possibly lobelin by hypodermic and dilation of the rectum are respiratory stimulants. On the operating table artificial respiration may be given to the patient by slowly drawing both his arms high above his head and then slowly bringing them down to the sides so that the elbows are pressed into the sides of the chest. (See the section on Resuscitation.) Rebreathing of carbon dioxide and oxygen are useful in cases of embarrassed respirations. If the breathing is hindered because the jaw drops, the latter should be pushed forward by placing the thumbs behind *both* angles of the jaw. Pulling up the chin is not nearly so useful. When the tongue has dropped back it may be pulled forward with an instrument. Often the introduction of an "airway" (a curved metal tube which fits over the tongue) will be of use.

The technic of administration of spinal anesthesia is important, and the contraindications must not be disregarded.[131]

Critchley[132] says: "Spinal anesthesia may at times be followed by neurologic sequelae which, always disturbing in character, may even prove disastrous, if not fatal." He discusses headache, palsy of the abducens nerve, lesions of the cauda equina and conus medullaris, radiculomyelitis, sacral radiculitis and symptoms of neurologic disease precipitated by spinal anesthesia. Livingstone and his colleagues[133] report 2 cases of "aseptic or chemical meningitis" following novocain spinal anesthesia. Light and his colleagues[134] say: "A wide variety of neurological complications, either immediate or remote, may follow spinal anesthesia. The tables summarize the pertinent data. Undoubtedly many complications will go unrecognized unless careful postoperative neurological studies are made. That some of these complications may appear days, weeks, or even months after spinal anesthesia should be of definite interest to internist, surgeon, and anesthetist. Fortunately, these complications are relatively infrequent and should not deter the use of this anesthetic when it is indicated."[135] Lyford[136] found the incidence of postoperative infections of the respiratory tract among patients without infections of the respiratory tract at the time of operation to be with ether 5.8 per cent, with cyclopropane 4.9 per cent and with spinal anesthesia 7.5 per cent.[137] Woodbridge[138] says that at the present time spinal anesthesia is used almost to the exclusion of other types of anesthesia for abdominal operations at the Lahey Clinic. Several reasons are given for this: the fact that pontocaine and nupercaine, which are now used, produce longer anesthesia with less depression than do procaine and metycaine; the improved methods of management of patients under spinal anesthesia; the advantages of the relaxation which is produced; and the improvement in preliminary narcosis. It must be

remembered that *low* spinal anesthesia is far safer than high spinal anesthesia. Continuous spinal anesthesia is endorsed by Lemmon and Paschal.[139]

Of recent years *intravenous anesthetics* have found a definite place among the various anesthetic agents. Generally it is suitable for short surgical procedures, requiring from fifteen to thirty minutes.

Edwards and Hand[140] say: "In spite of the increasing use of pentothal as an anesthetic agent, one should not lose sight of its limitations. It is suitable for short procedures up to thirty minutes, and as a complement or supplement to other agents. At the Lahey Clinic [illegible] agent is still limited to minor procedures in which relaxation is [illegible] or complementary [illegible] oxygen, is routinely added.

"The cardinal points of its administration are: (1) slow injection; (2) the establishment and maintenance of a clear airway; (3) frequent pauses during its administration for an evaluation of the patient's condition and depth of anesthesia, and (4) keeping the necessary [illegible] and artificial respiration." Hunter[141] [illegible]

his patient's lungs with carbon dioxide and oxygen.[142]

Convulsions during general anesthesia have been reported.[143] Cross infections from anesthetic face masks have been studied by Livingstone and his associates.[144] Refrigeration anesthesia has been used for amputations (see the section on peripheral vascular disease) and for skin grafting.[145]

RESPONSIBILITIES OF THE ATTENDING SURGEON TO THE INTERN

The attending surgeon's first duty to the intern is to see that he has the opportunity to learn surgery. As W. Wayne Babcock[146] says, he should give him systematic instruction. "Every patient in the hospital should be accessible to the intern."[147] The surgeon should go out of his way to show him interesting pathologic conditions, and he should explain fully to him the reasons for the various therapeutic measures which he employs. He should stimulate the intern by questions and should encourage him in his collateral reading and attendance at medical society meetings. He should insure proper discipline among the interns. Careless work or laziness should be censured. *He should endeavor to delegate responsibility* as far as is possible to the intern. Responsibility increases the self-respect of the intern and his capacity for original thought. In his relation to patients the attending surgeon courteously introduces his intern as a colleague. He always takes the intern with him to see his patients unless there are very special reasons for not doing so. He should strive to set a good example for the intern in his intellectual approach to surgical problems and in his attitude toward patients. It is often wise occasionally for the surgeon to invite the intern to his house to dinner to meet his family and to see his library. He should at all times try to stimulate the intern to undertake original investigation, a stimulus which is often accomplished by letting the intern see his own interest in clinical or laboratory research. He should try to have the intern perform all the operations that he is capable of handling and should take pains to guide and encourage his first surgical efforts. In no event, however, should he subordinate the patient's welfare to the intern's profit. The surgeon should take the time and

pains to read all the records which the intern has written and to criticize them if necessary. The surgeon should remember that the intern is human and therefore susceptible to fatigue. He should be on watch that the intern's living quarters are adequately comfortable and that the intern is properly fed. *He should guide him away from contentions with nurses.* Follansbee[148] has emphasized several very important duties of the hospital staff to the intern. He says: "The intern should be a daily visitor with the attending physician to all the patients in his department, and the orders of the attendant should be made through him, with such discussion as will explain to him why such orders are made. . . . He should have the opportunity of making careful and complete examinations of all patients whom he visits. . . . He should be taught in detail and by personal example the proper care of accident work." Case[149] has said: "Much good will have been accomplished if the intern on leaving the hospital can carry with him a thorough appreciation of the *scope and limitations of the roentgen examination in various disease conditions*, its value and dangers in the control of fracture and foreign body work, and its place with radium in the treatment of many benign lesions as well as in the management of malignant disease."

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